SEWAGE AND INDUSTRIAL WASTES

(Formerly Sewage Works Journal)

JOURNAL of the FEDERATION OF SEWAGE AND INDUSTRIAL WASTES ASSOCIATIONS

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Oxygen Use in Biological Treatment—Budd and Lambeth

Organizing Stream Studies—Scott et al.

California Cannery Wastes—O'Connell

Pollutional Effects of Hydraulic Power—Ingols

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1957 YEAR BOOK AND SUPPLEMENTAL DIRECTORY

MARCH, 1957—VOL. 29, No. 3

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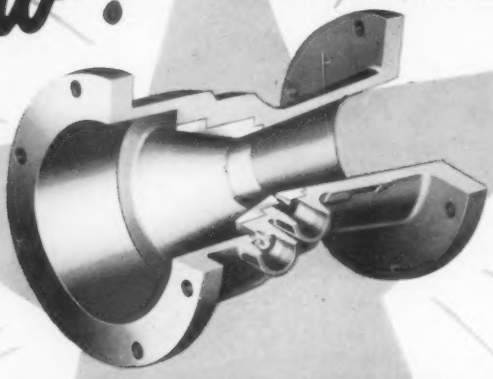

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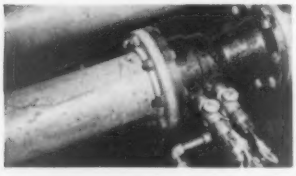

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Architect's drawing of the Louisville, Kentucky refuse incineration plant—Joseph and Joseph, Architects. Not illustrated is the new Sewage Treatment Plant, Metcalf and Eddy, Engineers.

LOUISVILLE USES REFUSE TO DISPOSE OF SEWAGE SLUDGE

The City of Louisville, Kentucky is currently building a new sewage treatment plant and—several miles away—a new refuse incinerator plant.

Rather than incorporate sludge disposal facilities in the new treatment plant, the City will truck filter cake to the refuse incinerators. There, two C-E Raymond Flash Drying Systems will utilize the waste heat from the incinerators to dry the filter cake for use as a fertilizer or prepare it for burning in the incinerator with the refuse. For Louisville, this combination of facilities offers a number of advantages. Among them are—

Least First Cost for a system capable of drying, incinerating and deodorizing. The refuse incinerator eliminates the need of a separate drying furnace.

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Maximum Flexibility since the City can dry any amount of sludge for sale as a fertilizer or for use on municipal golf courses, parks and lawns. Any unused sludge can be incinerated with the City's refuse.

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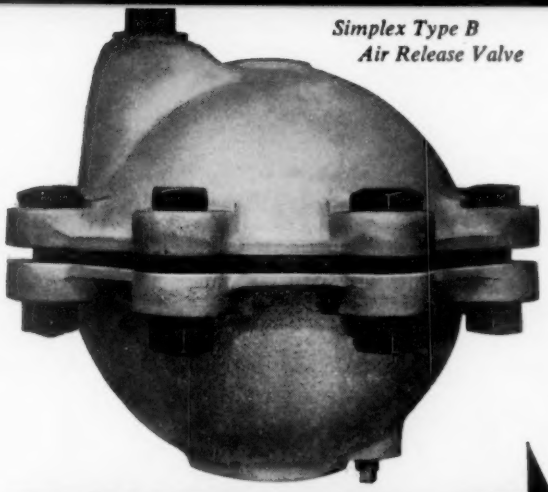

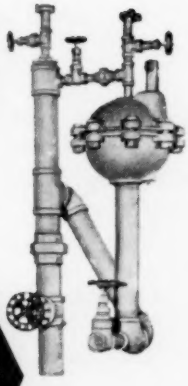

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Arkansas Water & Sewage Conf.	Marion Hotel Little Rock, Ark.	Mar. 18–20, 1957
Louisiana Conference on Water Supply and Sewerage	Univ. of Louisiana Baton Rouge, La.	Mar. 20–22, 1957
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Montana Sewage and Industrial Wastes Assn.	Rainbow Hotel Great Falls, Mont.	Apr. 4, 1957
Arizona Sewage and Water Works Assn.	Maricopa Inn Mesa, Ariz.	Apr. 4–6, 1957
Kansas Sewage and Industrial Wastes Assn.	Broadview Hotel Wichita, Kans.	Apr. 10–12, 1957
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Iowa Sewage and Industrial Wastes Assn.	Hotel Kirkwood Des Moines, Iowa	June 19–21, 1957
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Institute of Sewage Purification	Margate, England	June 25–28, 1957
Central States Sewage and Industrial Wastes Assn.	Sherman Hotel Chicago, Ill.	June 26–28, 1957

THIRTIETH ANNUAL MEETING

Federation of Sewage and Industrial Wastes Associations
in conjunction with
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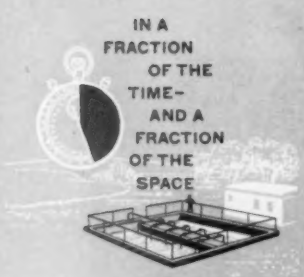
Statler Hotel, Boston, Massachusetts
October 7–10, 1957



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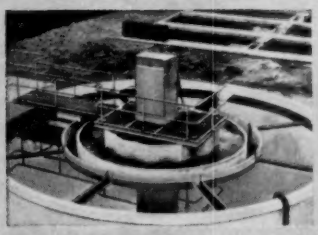

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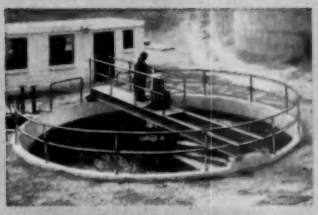
activated sludge plants compact and efficient

High-rate, multipurpose unit. Rapid, continuous biological action and clarification, efficient operation at high loadings, stability under shock conditions. Low total installed cost. Bulletin 6510



BIOSORPTION®

system units twice as fast—save half the space

Improved activated sludge plant treats sewage in about 5 hrs. as compared to 10-12 hrs. for traditional equipment. Very compact, economical to install. Bulletin 6550

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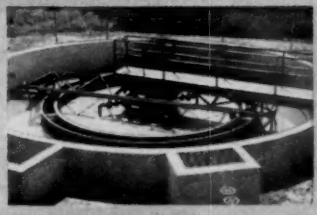
for high rate treatment provide optimum efficiency —save time and space

Remove suspended solids and surface scum from liquids. Velocity control, advanced scraper blade design, efficient drive, automatic skimmer. Full range of models. Bulletin 800/6000



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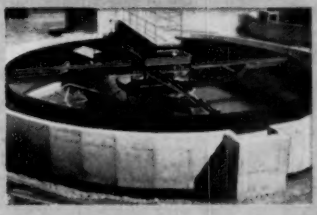
clarifier, Type AR, for many waste applications

Treats domestic sewage by biological oxidation. Combines pre-aeration, mixing, sedimentation and discharge in one operation. Basin has central compartment containing COLAFLEX® diffusers in which sewage is mixed, aerated and coagulated Bulletin 850



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clarifiers provide both sedimentation and flotation in one compact unit

Where space is limited and high-rate production a must this unit is ideal for removing both floatable materials and settleable solids Bulletin 6051

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6 to 10 Times More Bearing Contact Area

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With long wearing bronze bearing surfaces on beams and downstream discs, this Chapman Valve is just the valve you need for filtration plants, wash water valve service or other places where limited throttling is in order. Available in all standard sizes with any desired method of operation.

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Economical solution to a pollution problem

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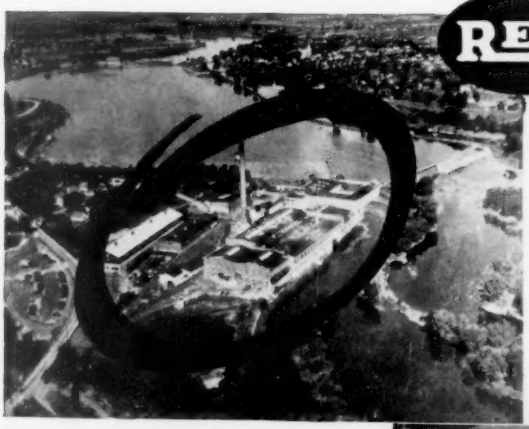

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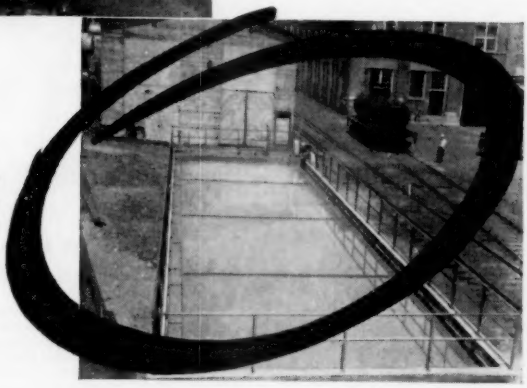


In their current anti-pollution program, why did Combined Locks Paper Company choose Rex Verti-Flo? Because of the design, installation and operating economies assured by this unique clarifier.

Rex Verti-Flo design divides a horizontal-flow settling tank into a series of smaller, vertical-flow cells. This unique cellular construction assures up to four times more tank capacity than conventional settling tanks. Detention times are from one-fourth to one-half those required in conventional tanks...and the effluent is of maximum clarity.

Translated into dollars and cents, here are what those advantages mean: lower construction and equipment costs since smaller tanks can be used, lower operating costs, lower maintenance costs.

Rex Verti-Flo is available in "packaged" steel tanks for smaller flows or in concrete tanks for larger flows. Why not get complete information? Send for your copy of Bulletin 315-92, "Packaged Industrial Waste Treatment." Write CHAIN Belt Company, 4606 W. Greenfield Ave., Milwaukee 1, Wis.

CHAIN BELT COMPANY

Milwaukee 1, Wisconsin

will it come to this again?

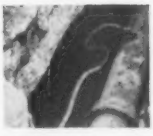
In the Old West, the waterhole meant life. And men frequently defended one with their lives.

Today's need for water . . . if not as dramatic . . . is even more urgent. Our population has doubled since 1900. But our water requirements have quadrupled! Meanwhile, average rainfall does not vary from year to year. And erosion of moisture-bearing soil continues.

You can help stem this terrific drain on our water sources.

1. Encourage water officials to plan ahead.
2. Support realistic water rates and water supply bond issues.
3. Conserve water wherever you possibly can.

Water means life for *you*, too.



SERVES FOR CENTURIES!

You and your great-grandchildren will reap the benefits of the cast iron pipe installed today.

One example: this cast iron water main laid in Detroit 126 years ago is still serving efficiently. Throughout the country are many more century old cast iron water and gas mains.

Long life, dependability, minimum maintenance. These are the qualities water officials seek. And cast iron delivers them more than any other pipe!

CAST IRON PIPE
RESEARCH ASSOCIATION — 122 SOUTH MICHIGAN AVENUE, CHICAGO 3, ILL.

MODERNIZED **cast iron**

YOUR PROBLEM IS HERE ...AND NOW!

No one knows better than you . . . that where water is concerned, *time is running out.*

We can't wait years for the public to learn by bitter experience that its water supply must keep pace with increasing needs. America must be told *now.*

Advertisements* like the one opposite do exactly that. By reaching millions and hammering home the facts about water, they make it easier for *you* to enlist the support of your community for your water proposals.

CAST IRON

Cast Iron Pipe Research Association, Thos. F. Wolfe, Managing Director, 122 So. Michigan Ave., Chicago 3, Ill.

* *Appearing in:* Saturday Evening Post, Newsweek, U. S. News & World Report, Nation's Business

pipe FOR MODERN WATER WORKS

32. *Method of Treating Plating Waste*

RECOVERY? DISPOSAL?

There is no one process that will solve all plating waste problems. Experience has shown staff and consulting engineers that the correct solution can be obtained only by thoroughly evaluating all the factors in each case.

Whether the answer is recovery, disposal or a combination of both, Graver has complete equipment to do the job. Graver's 50 years of liquid treatment experience has resulted in equipment of advanced designs and engineered flexibility to suit individual requirements.

WRITE FOR TECHNICAL ARTICLE AND BULLETINS:
T-136: Plating Waste Solutions; Recovery or Disposal
WC-103A: Reactivators • WC-111: Ion Exchangers

GRAVER®

Industrial Waste Treatment Dept: W-211

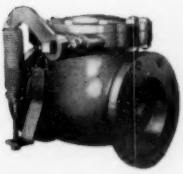
GRAVER WATER CONDITIONING CO.

Division of Graver Tank & Mfg. Co., Inc.

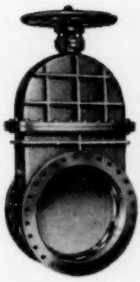
216 West 14th Street, New York 11, N. Y.

Specify IOWA for every job

Iowa's complete line of valves for treatment plants assures you of efficient operation, low maintenance cost, and replacement parts when needed in years to come.



IOWA CHECK VALVES—Swing gate type for use in either horizontal or vertical pipe lines. Bronze trimmed throughout. Stainless steel hinge pins. Leather or rubber faced gates, or solid bronze, as desired—aluminum gates available for air service.



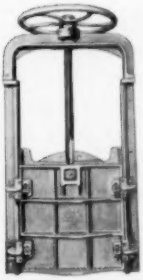
IOWA MEDIUM AND LOW PRESSURE VALVES—either non-rising stem or outside screw and yoke types. Designed as carefully as those conforming to A.W.W.A. specifications but with lighter construction for lower pressures.

Write TODAY for descriptive literature

IOWA FLAP VALVES—all iron; can be furnished with bronze hinge bolts or fully bronze mounted—including bronze bolts, flap ring and seat ring—when required.

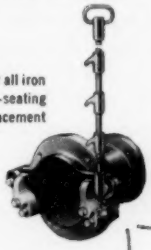
CLOW HYDROSTATIC RELIEF VALVES — commonly used in bottom of concrete tanks to prevent ground water from floating the tank. Close-grained cast iron body and lid; lead seat ring and lid ring. Cast iron grate in bottom prevents foreign matter from entering tank.

IOWA PLUG DRAIN VALVES—either rising or non-rising stem type. High strength cast iron bodies; bronze stem, operating nut, disc ring and seat ring; rustproof steel bolts and nuts. Handwheels, extension stems, plain or indicating floor stands if required.



IOWA SLUICE GATES—can be used in lines having both seating and unseating pressures. High strength cast iron, bronze mounted, with solid bronze adjustable wedges. Can be equipped with cylinder or motor unit for automatic operation.

IOWA SHEAR GATES—either all iron or iron, bronze mounted. Gate-seating wedges bolted on, permitting replacement without replacing frame.

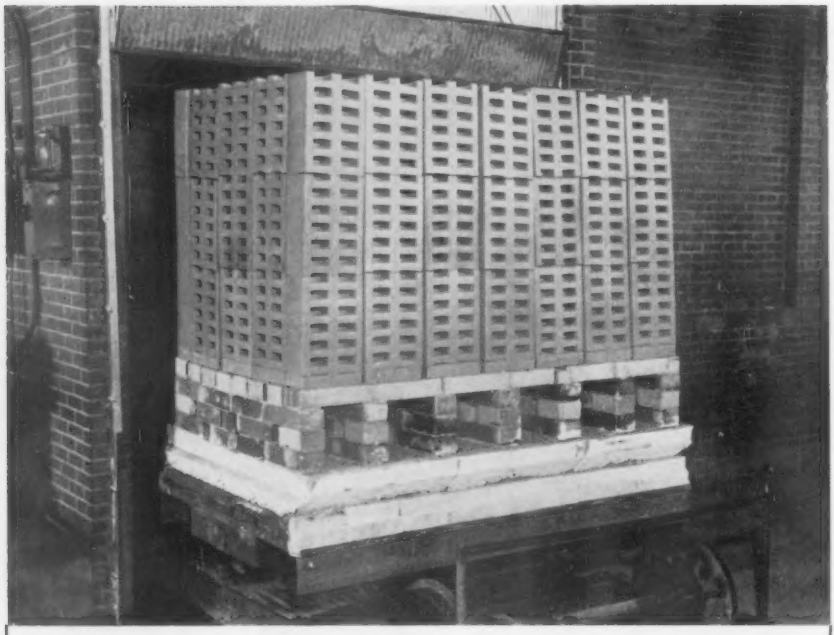


For 45 years a reliable source for **precision engineered products**

IOWA VALVE COMPANY

A Subsidiary of James B. Clow & Sons

Oskaloosa, Iowa



We're *Firing* Your Most Dependable *Helper!*

This is a carload of Bosco Trickling Filter Underdrain Block entering the preheat zone of our tunnel kiln. In a period of 26 hours these blocks will gradually rise in temperature to 1700° F. degrees from hot gases directed under the firebrick deck or the car as it passes from zone to zone in the kiln. "Firing" fuses the particles of shale into a solid mass or vitrified material, inert in nature, with high structural strength, creating a silent dependable helper for use in your trickling filter.

Bosco Underdrains *are* dependable helpers. They provide ventilation for the growths in the filter and drainage for the treated effluent, and they will continue to do so for the life of the filter. Properly installed underdrains never tire.

For prices and estimating data please write Box 81, Bowerston, Ohio. Ask for a free "Handbook of Trickling Filter Design."

BOSCO

Reg. U.S. Patent Office

The Bowerston Shale Company
P.O. Box 81
Bowerston, Ohio

Preset totalizer shows remaining chlorine supply and warns when supply is low. Separate alarm warns of system failure.

Continuous visual record assures efficient use of Chlorine

EFFICIENT USE OF CHLORINE puts money in your pockets. Comparison of chlorine and main line flow records provides a continuous safeguard against wasted chlorine or insufficient dosage by continuously monitoring the accuracy of the system.

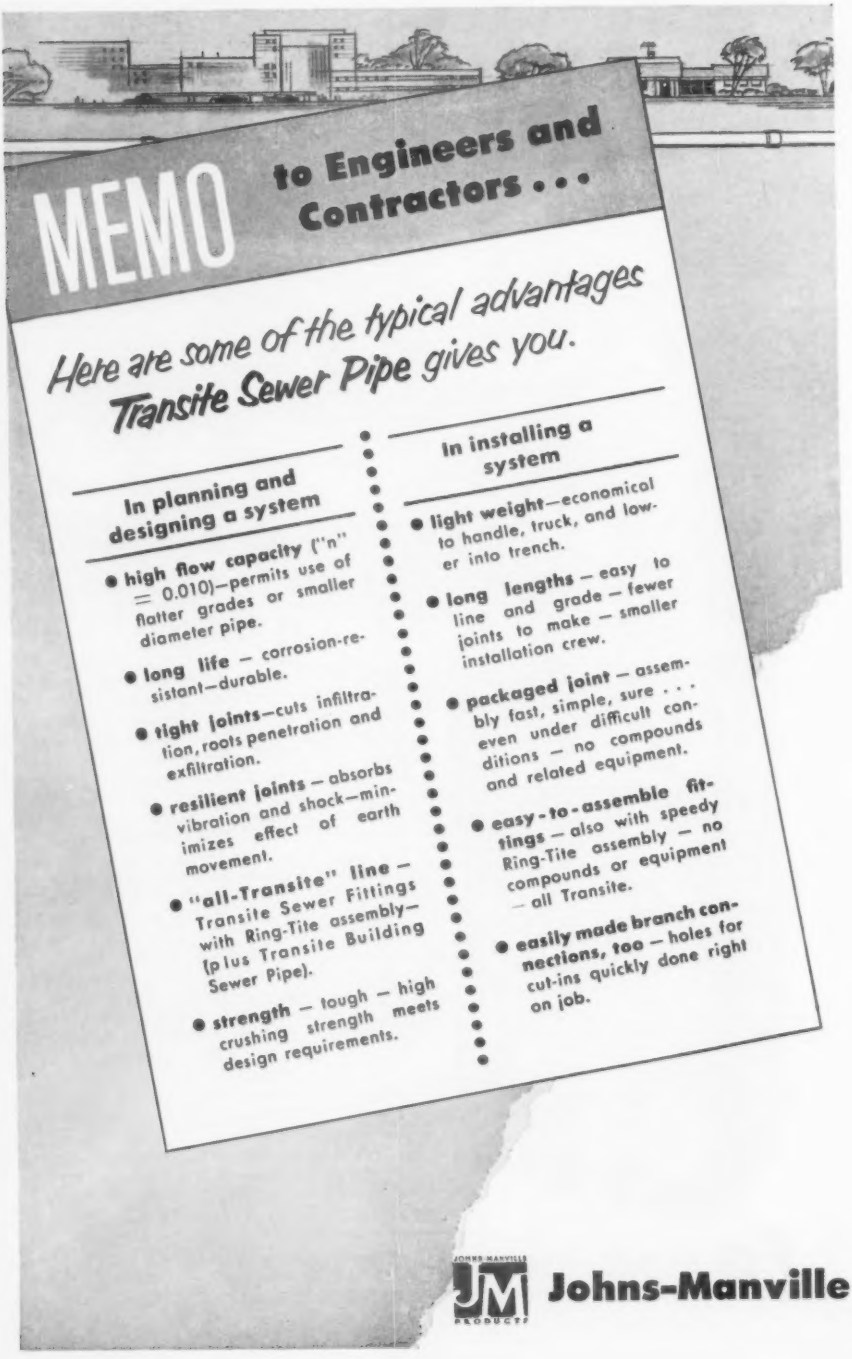
This recording system is readily adaptable to most chlorinators of all manufacturers.

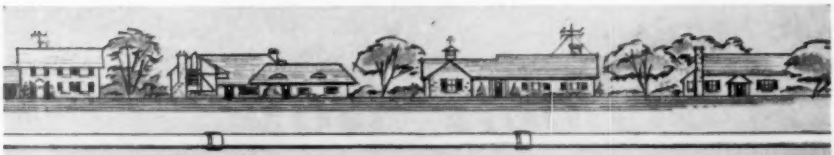
A simple screwdriver adjustment permits field synchronization of the flow recorder with the interchangeable capacity of the chlorinator. Indicators, totalizers, transmitters and high-low alarms are available for use in this F&P Chlorine Flow Recording System. These functions may be located remotely by the use of F&P pneumatic or electric transmission systems.

Every part is completely corrosion resistant. Magnetic coupling eliminates the need for trouble-making pressure tight bearings.

Write today for complete information or detailed proposals and quotations to Fischer & Porter Co., 1137 Fischer Road, Hatboro, Pennsylvania.

FP FISCHER & PORTER CO. Hatboro, Pa.
COMPLETE PROCESS INSTRUMENTATION


MEMO to Engineers and Contractors . . .
Here are some of the typical advantages Transite Sewer Pipe gives you.
In planning and designing a system
• high flow capacity ("n" = 0.010)—permits use of flatter grades or smaller diameter pipe.
• long life — corrosion-resistant—durable.
• tight joints—cuts infiltration, roots penetration and exfiltration.
• resilient joints — absorbs vibration and shock—minimizes effect of earth movement.
• "all-Transite" line — Transite Sewer Fittings with Ring-Tite assembly—(plus Transite Building Sewer Pipe).
• strength — tough — high crushing strength meets design requirements.
In installing a system
• light weight—economical to handle, truck, and lower into trench.
• long lengths — easy to line and grade — fewer joints to make — smaller installation crew.
• packaged joint — assembly fast, simple, sure . . . even under difficult conditions — no compounds and related equipment.
• easy-to-assemble fittings — also with speedy Ring-Tite assembly — no compounds or equipment — all Transite.
• easily made branch connections, too — holes for cut-ins quickly done right on job.
JOHNS MANVILLE PRODUCTS
Johns-Manville

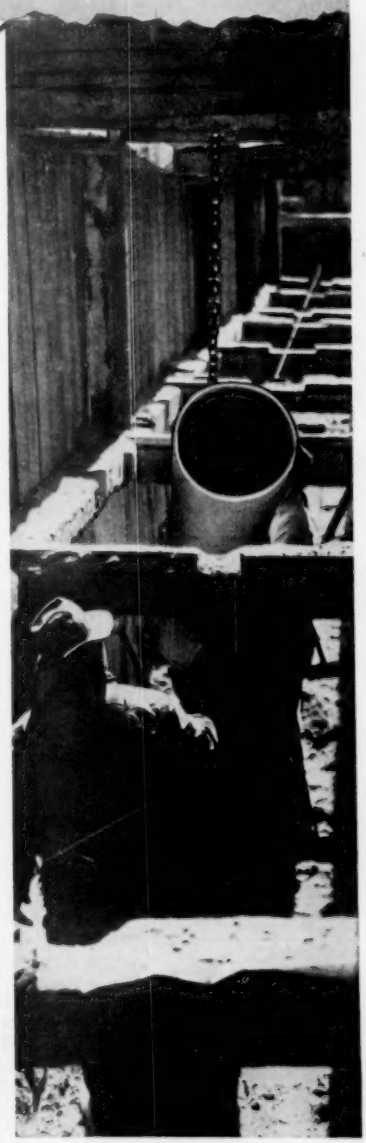


Select

Transite® for more economical, tighter sewerage systems . . .

WHETHER a new sewerage system is being planned or additions to an existing one are being made . . . engineer and contractor alike will find a combination of qualities in performance-proved Transite Sewer Pipe that will fit their individual needs. They will find this holds true whether the local conditions call for (a) tight joints to protect against root growth and infiltration of ground water or (b) the strength and flow characteristics that mean definite savings in the design stage, during trenching and installation, and in operation as well.

For further information about Transite Sewer Pipe, write for Booklet TR-165A, Johns-Manville, Box 14, N. Y. 16, N. Y.



TRANSITE SEWER PIPE
with the RING-TITE® Coupling

A School? No!

*This plant was designed by Henry W. Taylor, Freeport, N. Y

It's an

INCINERATION PLANT

serving Hempstead, N. Y.

- **Large but not an eye-sore**
- **Efficient and flexible**

Serving some 450,000 people, this plant provides an excellent example of the way larger communities are handling their refuse problems. Land-filling can no longer be tolerated in the suburban areas and should not be tolerated *anywhere*. Yet, there's no need to have an incinerator plant that's offensive to the nose and eye. Modern design and modern operation take care of the nuisance factors.

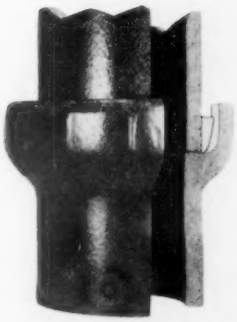
For this Hempstead plant, we furnished four Morse Boulger Mechanically Stoked Furnaces for handling up to 700 tons of refuse per 24 hours. Waste heat boilers recover much of the heat and provide steam for two 1000 kw. turbo-generators. Our engineers also furnished the crane charging equipment, stacks, fly ash removal unit and ash removal conveyor.

What we did to help in this Hempstead project we can do to help you...working with your sanitation engineer or your consulting engineer. The point to keep in mind is that your community, too, can have clean, efficient, nuisance-free refuse disposal in a modern incineration plant such as this Morse Boulger plant.

MORSE BOULGER DESTRUCTOR CO.

DEPT. E-80 FIFTH AVENUE • NEW YORK 11, N. Y.

Neither Rain, Nor Sleet, Nor Mud . . . slowed the installation of this AMVIT* LINE



If you can dig the trench, you can install Amvit Jointed Clay Pipe. Bad weather and mud won't slow the laying of an Amvit line.

The joint is on the pipe delivered to the job ready for use. Nothing else is needed. Just push the pipe together and the joint is complete.

No other materials such as caulking, joint compound, joint runners, hot-pots, or ladles are needed to make the Amvit Joint. Savings on materials and labor mean *lower cost of pipe in place.*

Amvit is a compression type joint on the ball and socket principle. No adhesives or other compounds are needed to make a tight seal. Once the joint is complete, nothing can enter or leave the line.

Amvit Jointed Clay Pipe, in sizes 4" through 24", together with all fittings, is available for immediate delivery in the Northeast and Central States.

For more information and our new Amvit brochure, write or call American Vitrified Products Company, National City Bank Building, Cleveland, Ohio, or our office nearest you.

SINCE 1900

AMERICAN

American Vitrified Products Company

CLEVELAND, OHIO

*T. M. Registered. Patents Pending

The Amvit joint is made of an acid resistant plastic material with rubber characteristics. Like the pipe, the joints will not be harmed by any condition of underground service. The pipe is simply pushed together. The trench is then ready for backfilling.

MANUFACTURERS of: Clay pipe, flue liners, clay liner plates and concrete pipe.

Plants Across the Nation...Brazil, Indiana • Chicago, Illinois • Cleveland, Ohio • Crawfordsville, Indiana • Detroit, Michigan • East Liverpool, Ohio Fenton, Michigan • Grand Ledge, Michigan • Lisbon, Ohio • Los Angeles, California • Milwaukee, Wisconsin • South Bend, Indiana • Uhrichsville, Ohio

REMOVE GRIT

Easily—Thoroughly—at Low Cost

COMPLETE EQUIPMENT
to do the complete job!

PROVIDES CONSTANT OPTIMUM VELOCITY
POSITIVE ADJUSTMENT FOR VARYING FLOWS
HYDRO-DYNAMIC WASHING
AUTOMATIC DRAINING AND REMOVAL

FLOW CONTROLS—exclusive Camp Channel Section and Regulator* maintain constant optimum velocity for effective grit settling, regardless of rate of flow through plant. Velocity can be easily and instantly adjusted to meet changing conditions. Minimum head loss.

*Patented

CONVEYOR—single strand, continuous drag type. Flights carry the settled grit from channel bottom to hopper for washing and removal.

HYDROWASH UNIT—washes grit free of organic matter by producing a turbulent downflow recirculation and agitation of liquor in grit hopper. Organics returned to hopper.

ELEVATOR—totally enclosed, tube type, for slow and continuous removal of washed grit from the hopper. Grit drains as it is being elevated through the tube.

Write for Bulletin No. 249B

Technical Supplement "CR", containing complete design data on the AMERICAN CAMP GRIT CHANNEL *and* REGULATOR, *is available on request with Bulletin 249B.*

AMERICAN WELL WORKS

IN OUR 87TH YEAR
110 North Broadway
AURORA, ILLINOIS

Pumping, Sewage Treatment, and Water Purification Equipment
RESEARCH · ENGINEERING · MANUFACTURING

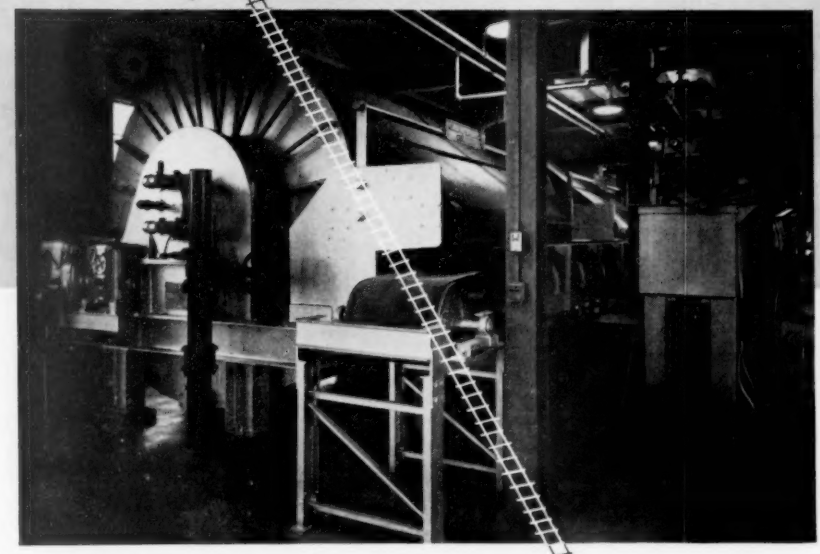
Offices: Chicago · New York · Cleveland · Cincinnati · Kansas City · Sales Representatives throughout the World

Louisville & Nashville now to be served

by two

"Old Reliables"

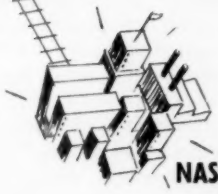
LOUISVILLE



In railroads it's the L & N—in sludge vacuum filters, it's the COILFILTER. Both have earned the nickname "The Old Reliable" through years of faithful and dependable service.

Louisville's new plant will include three 430 sq. ft. COILFILTERS. Metcalf & Eddy, Engineers.

Nashville will have two 300 sq. ft. COILFILTERS. George P. Rice, Consulting Engineer. The Chester Engineers, Consultants.



NASHVILLE

KOMLINE-SANDERSON ENGINEERING CORPORATION

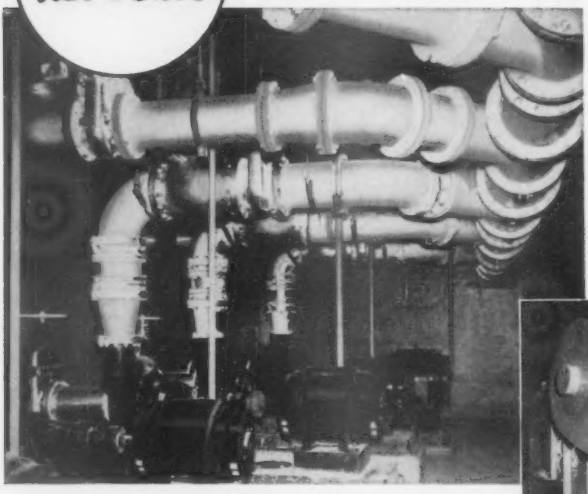
Peapack, New Jersey

MANUFACTURERS OF COILFILTER SLUDGE VACUUM FILTERS

CO$T-REDUCING

INERTOL® PAINTS

Specified for Rochester, Minnesota, Sewage Plant



● **Pump Gallery:** Piping and equipment painted with *Glamortex® Enamel,* finest quality alkyd, in color, to assure a long-lasting, fade-resistant finish.

● **Walls and ceilings** throughout this modern plant, like those of the room housing the Link-Belt Grit Collector, are guarded with *Ramuc® Utility Enamel,* chlorinated natural rubber-base. Colorful *Ramuc* is easy to clean, chemical-resistant and won't saponify. It affords top maintenance economy as well as durable protection.

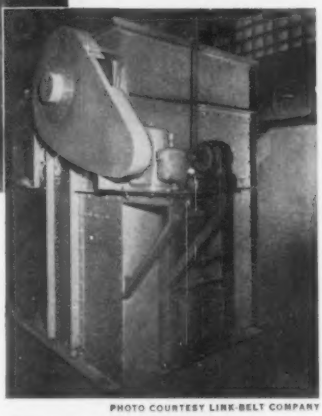


PHOTO COURTESY LINK-BELT COMPANY

Specified by Engineers Toltz, King & Day, Inc., St. Paul, Minnesota, to fully protect this $2,000,000 plant

Since 1937, Inertol coatings have been used by the city of Rochester—world-famous medical center. Like hundreds of municipalities across the country, it has found that Inertol assures long-term protection plus considerable maintenance savings.

Hardness . . . elasticity . . . chemical inertness...beauty—these Inertol qualities explain why the Rochester plant is another 100 per cent Inertol job.

Buy Inertol paints direct from the manufacturer! Shipment within three days from our plant, or from nearby warehouse stocks. For full details about Inertol paints, send for free, comprehensive "Engineers' Painting Guide." Just write us on your firm's letterhead, giving your title.

Be sure to inquire about Rustamor,® Inertol's new hygroscopically controlled rust-neutralizing paint.

A Complete Line of Quality Coatings for Sewage Plants and Water Works

Inertol

INERTOL CO., INC.

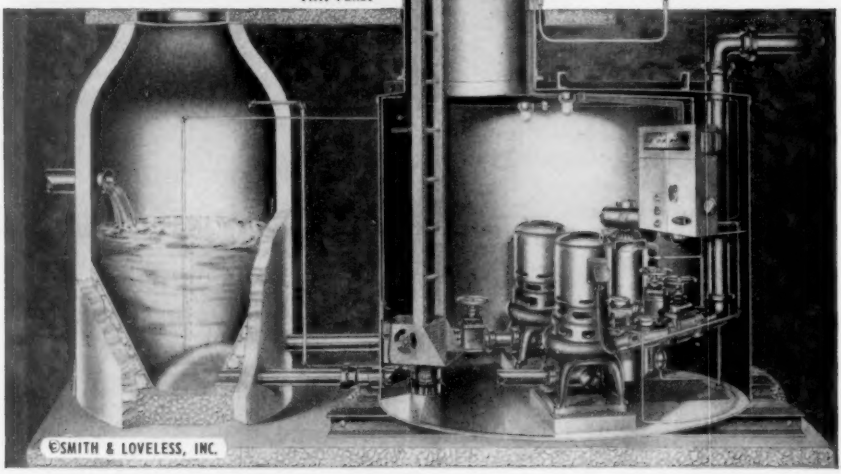
482 Frelinghuysen Avenue, Newark 12, New Jersey
27H South Park, San Francisco 7, California

HUNDREDS OF INSTALLATIONS—IN 27 STATES!

Smith & Loveless
FACTORY-BUILT PUMPING STATION

PROVEN QUALITY—
WITH FACTORY-BUILT SAVINGS

PAT. PEND.



We specialize in building America's finest sewage lift stations. Acceptance proves their quality. Smith & Loveless offer you a complete line of six standard size lift stations with capacities from 20 GPM to 1600 GPM per pump or ejector. Larger capacity stations are built to your order.

- An integrated design, each piece proven by the test of time.
- Precision assembled by factory experts.
- Automatic dehumidifier to eliminate condensation.
- A central electrical control cabinet prewired and color coded.
- Shot blasted steel structure epoxy coated plus cathodic protection.
- Factory tested and adjusted by actual operation before shipment.
- Easily and quickly installed.
- Especially designed for minimum maintenance.

For Job Recommendations, complete specifications, and drawings — all part of the latest edition of the 100 page Smith & Loveless lift station Data Manual . . .

WRITE DEPARTMENT 30

S&L

Smith & Loveless, Inc.
P. O. BOX 8172 KANSAS CITY, MISSOURI
Manufacturing Plant • Merriam, Kansas

REPRESENTATIVES IN PRINCIPAL CITIES

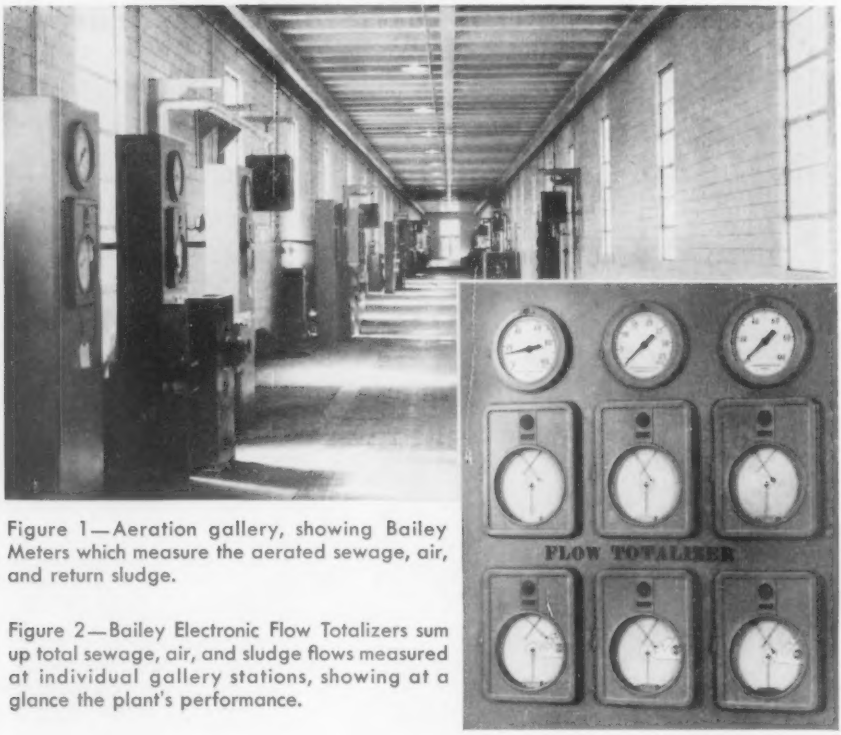


Figure 1—Aeration gallery, showing Bailey Meters which measure the aerated sewage, air, and return sludge.

Figure 2—Bailey Electronic Flow Totalizers sum up total sewage, air, and sludge flows measured at individual gallery stations, showing at a glance the plant's performance.

Havens & Emerson—Consulting Engineers

FLOW TOTALIZATION – at Southerly Sewage Treatment Plant

Instantaneous plant performance and operating trends are continuously available to supervisors and operators through Bailey's Electronic Flow Totalizer.

The new 32 MGD addition to the Southerly Sewage Treatment Plant, Cleveland, Ohio is equipped with Bailey Flow Meters, Integrators, Indicators, and Recorders.

Complete instrumentation and automatic controls for sewage and industrial waste treatment plants are engineered and manufactured by Bailey to meet the most rigid requirements of any size plant.

If you are planning new construction, a Bailey Application Engineer will be pleased to help you lay out your instrument and control requirements. MU-26

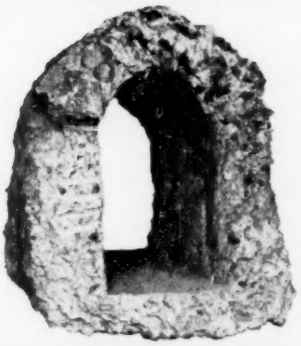
WATER & WASTE TREATMENT DIVISION

BAILEY METER COMPANY

1066 IVANHOE ROAD • CLEVELAND 10, OHIO

In Canada—Bailey Meter Company Limited, Montreal

BAILEY METERS



CONCRETE FACT — This is a section of the Roman aqueduct between Eiffel and Cologne, built in 80 A.D., in use continuously until 1928. A natural cement occurring along the Rhine between Cologne and Coblenz was used by Roman army engineers in building the aqueduct. (Photo, courtesy Smithsonian Institute, Washington, D. C.)

THE ENGINEERS OF TITUS

built for the ages with . . .

CONCRETE

1848 years of continuous, dependable service!

The army engineers of Fabius Sabinus Titus, Emperor of Rome, knew their business when they put down the original aqueduct to serve the water needs of the conquered city of Cologne, Germany. Extending 56 miles underground, between Cologne and Eiffel, *this rugged, cement-base conduit was built in 80 A. D. — served as the main artery for the Cologne water supply until 1928!*

Since the days of the chariot, men who know the problems of moving water for growing cities have relied on concrete. Lower in initial cost, dependable, economical **Concrete Pressure Pipe** is increasingly the choice of far-sighted community water planners. For long life, high carrying capacity and ease of installation, no other pipe can compare with it.

Concrete Pressure Pipe combines:

1. The Strength of Steel
2. The Durability of Concrete
3. The Simplicity, Flexibility and Safety of Rubber Gasket Joints

Water for Generations to come

Concrete PRESSURE Pipe

AMERICAN CONCRETE PRESSURE PIPE ASSOCIATION

228 North LaSalle Street
Chicago 1, Illinois

CLEAR CHOICE in Coagulants

GENERAL CHEMICAL Alum

Fact: most water and sewage treatment officials prefer General Chemical Aluminum Sulfate. *Reason:* they know they can depend on General Chemical for alum of unvarying quality and uniformity . . . for prompt, on-the-dot delivery.

There are 25 General Chemical producing works strategically located across the country to assure you of dependable service anywhere, anytime! Even in emergencies, *you can always count on General.*

Basic Chemicals for American Industry

CLEAR CHOICE FOR WATER TREATMENT

- Produces crystal clear water
- Gives better floc formation
- Promotes better settling and longer filter runs
- Aids in reduction of tastes and odors
- Has no chlorine demand
- Is a low-cost coagulant
- Superior in tests against other coagulants
- High in quality, its constant uniformity can be depended upon

CLEAR CHOICE FOR SEWAGE TREATMENT

- Clean, easy to handle
- Dry feeds well or dissolves readily for solution feeding; liquid alum also available in many areas
- Clear, colorless effluents are possible
- Simple application. Requires only low-cost feeding apparatus and minimum attention
- Sludge digests readily
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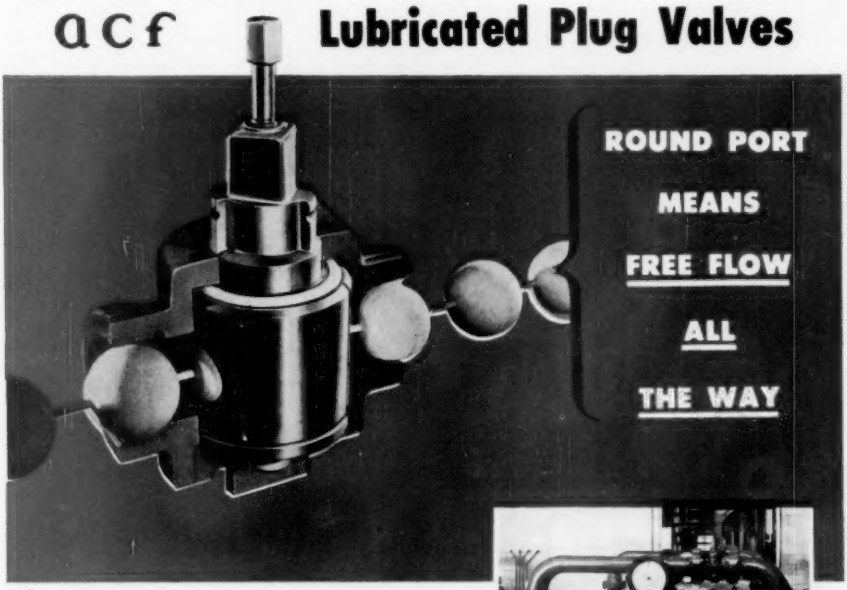

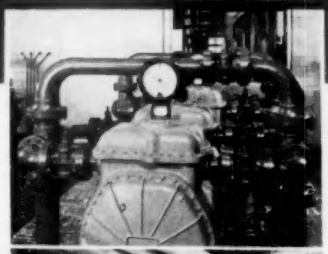

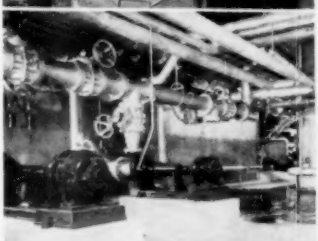

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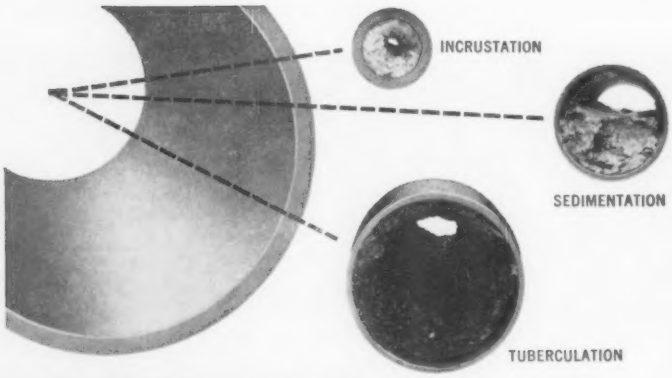

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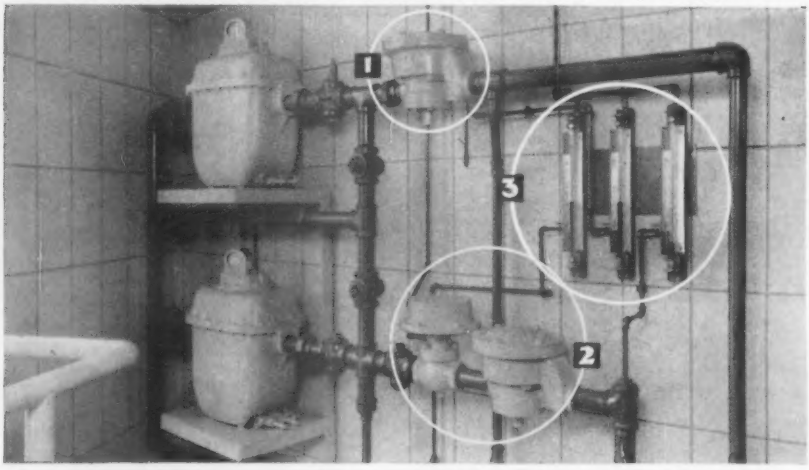
PFT Gas Safety Equipment in the Control Building at the new Morris plant. See description below.



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Plant Superintendent G. B. Reagen checks operation of the PFT #250 Heater & Heat Exchanger.

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SEWAGE AND INDUSTRIAL WASTES

Journal of the Federation of Sewage and Industrial Wastes Associations

Volume 29 | March, 1957 | Number 3

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Aerial view of the Ada plant taken in 1954 shortly after starting up. Clariflocculator unit at left. Consulting Engineer: Ralph W. Delaney, Ada, Oklahoma.

DORRCO CLARIFLOCCULATOR

Used in New Ada, Oklahoma, Plant

LOW RATE TRICKLING FLOWSHEET

Typical of many U. S. cities, the problem of a steady growth of population in Ada, Oklahoma, resulted in badly overloaded sewage treatment plant facilities. By the late 1940's, it was apparent that the original plant built in 1939 was completely inadequate to handle the increased flow. Rather than expand existing facilities, studies made by the city indicated that it would be more economical to build an entirely new 3 MGD plant.

In designing the plant, Consulting Engineer Ralph W. Delaney of Ada, Oklahoma, incorporated a 70 ft. dia. Dorrco Clariflocculator mechanism in the flowsheet to handle the flocculation and clarification steps. In addition to this combination unit, equipment at the Ada plant includes a Dorr Detritor unit for grit removal, a 168 ft. dia. Dorrco Distributor for low rate trickling filter treatment, a 75 ft. dia. Dorr Final Clarifier and a Dorr Multdigestion System.

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Sewage Works

HIGH-PURITY OXYGEN IN BIOLOGICAL SEWAGE TREATMENT *

By W. E. Budd and G. F. Lambeth

Respectively, Manager, Development Section and Development Engineer, Sanitary Technical Division, Dorr-Oliver Inc., Stamford, Conn.

The use of pure oxygen in the treatment of sewage by the activated sludge process is practical and can be economically justified, particularly for large plants in confined areas. These conclusions are based on extensive pilot-plant operations at Stamford, Conn.

It has been known for sometime that the use of pure oxygen would make possible an increase in dissolved oxygen saturation levels approximately four times greater than those with air. The high cost usually associated with the production of high purity oxygen, has restricted progress in the practical use of this potentially valuable tool in the biological treatment of sewage. Recently, however, new techniques have made it possible to produce oxygen at low costs. These advances raised the possibility that here was the tool that sanitary engineers had been looking for to improve the economic efficiency of the activated sludge system.

It is the purpose of this paper to present information on the use of high-purity oxygen in the biological treatment of sewage.

Historical Background

In October, 1946, Malcolm Pirnie, Consulting Engineer, prepared a memorandum entitled "Cheap Oxygen a Possible Tool in Sanitary Engineering (1)." Included was a layout of a proposed plant utilizing oxygen. The method consisted of aerating a mixture of settled sewage and recirculating the final effluent in an oxygenation column. The column effluent was discharged to a treatment tank containing a blanket of suspended biological floc. The oxygenated mixture contained a sufficient amount of dissolved oxygen to satisfy the requirements of the sludge in the blanket.

In 1947 Okun (2) conducted laboratory studies at the Harvard Graduate School of Engineering based on the information submitted by Pirnie, and concluded that the results were of sufficient promise to warrant consideration of the process, using low-cost "tonnage" oxygen as a means for sewage treatment.

Baltimore Pilot Plant

The favorable results obtained from the laboratory investigations led to the design and installation of a small-scale pilot plant † to evaluate this method of treatment on a somewhat larger scale. These investigations were carried out in 1953 at the Back River Sewage Treatment Plant, Baltimore, Md. The pilot plant was designed for a constant flow range between 10 and 30 g.p.m. and consisted of a 4-ft. diameter by 12-ft. sidewater depth upflow unit, with six 13.5-ft. long tapered

* Presented at the 29th Annual Meeting, Federation of Sewage and Industrial Wastes Assns.; Los Angeles, Calif.; Oct. 8–11, 1956.

† Furnished by Dorr-Oliver Inc., Stamford, Conn.

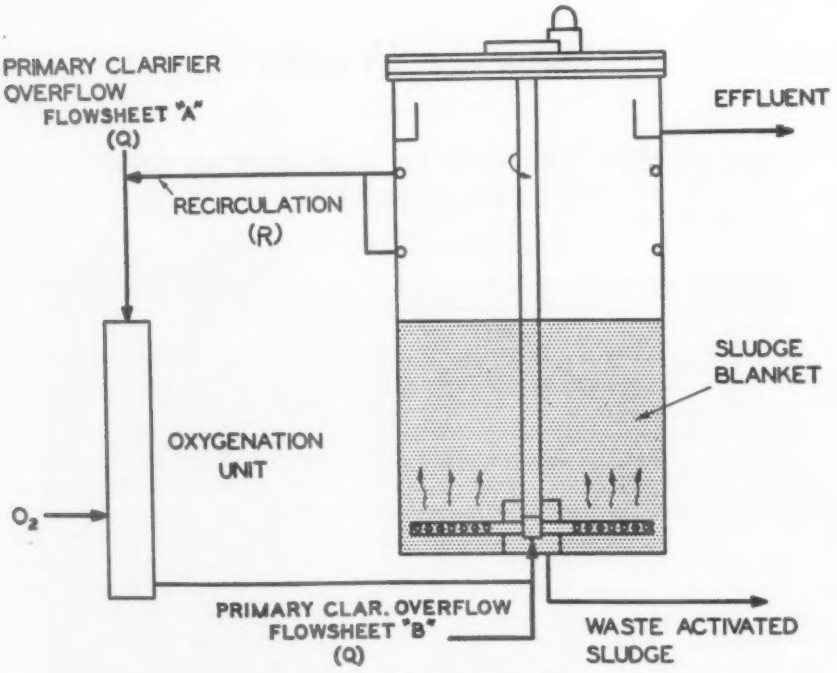

FIGURE 1.—Pilot-plant flow sheet.

tubes connected in parallel and used as oxygenation units. The basic flowsheet is shown in Figure 1.

From the experience and data obtained from this investigation, two basic conditions were found to be of utmost importance in the successful control of this system:

1. Economic handling and dissolving of oxygen in the sewage flow.
2. Control of the sludge settling characteristics in the upflow unit.

At the Baltimore pilot plant the oxygen absorption was carried out in columns with countercurrent flow and vented to the atmosphere. Absorption efficiencies obtained were in the range of 20 to 25 per cent. These efficiencies resulted in an oxygen feed rate of 1.005 tons per million gallons. No attempt was made to recapture the gas escaping to the atmosphere from the absorption columns which tested 45 to 50 per cent oxygen. These low absorption efficiencies indicated the need for further study.

Due to the upflow principle utilized in this system, it was realized that control of the sludge volume index at a low level would be necessary if reasonable overflow rates were to be attained. Accordingly, first priority was given to the maintenance of a balance between the food supply and the available organisms. In reviewing the operating data it appeared that this balance could best be maintained by using the parameter of pounds of 5-day B.O.D. per pound of suspended solids in the system per day, hereinafter referred to as the B.O.D. loading. It was observed that by maintaining the B.O.D. loading within certain limits a fast settling sludge was obtained. It was also observed that loadings above and below these limits resulted in a sludge with poor settling

characteristics, or a high sludge volume index. The optimum B.O.D. loading range was between 0.2 and 0.4 for the studies at Baltimore (3).

To be successful the two general and ever present problems of a biological system must be solved; first, the problem of supplying the required amount of oxygen for the organisms and secondly, to be able successfully and economically to clarify or separate these solids, thereby producing a stable effluent. It was also realized that other problems such as the stability of the system under a fluctuating load, control of sludge wastage, and mechanical and power efficiencies would need evaluation. In an attempt to meet these problems a second and larger pilot plant was constructed.

Stamford Pilot Plant

The second pilot plant, designed for a flow of 50 to 75 g.p.m., was erected at the Stamford, Conn., municipal sewage treatment plant early in 1955. The Stamford plant consisted of primary treatment facilities for an average flow of 7.5 m.g.d. The sewage received at the plant was considered to be representative municipal sewage. A typical analysis of the raw sewage and effluent at this plant is given in Table I.

The pilot plant at Stamford utilized essentially the same flowsheet as shown in Figure 1. It had two basic patterns, labeled "Flowsheet A" and "Flowsheet B." The difference between the two flowsheets was in the point of application of the settled sewage to the unit. In flowsheet "A", settled sewage was mixed with a portion of treated or final effluent and the combined flow was oxygenated prior to entrance into the upflow unit. Flowsheet "B" consisted of oxygenating final or treated effluent only, and the addition of settled sewage was made after oxygenation. The two flows were then mixed prior to entering the upflow unit.

The Stamford pilot plant was built around the principal treatment unit which was a 12-ft. diameter steel tank with a 22.5-ft. sidewater depth. This tank was equipped with a mechanism having four submerged rotating arms located at the bottom of the tank. Immediately adjacent to the tank, an equipment house was built which housed the various pumps and controls as well as the oxygen absorption column (Figure 2). Oxygen for the system was supplied in standard cylinders containing 277 cu. ft. of gas at a pressure of 2,500 p.s.i. The oxygen was discharged to the absorption column through a 16-cylinder manifold. The oxygen pressure at the manifold was reduced in stages through reducing valves to a final metered pressure of 15 p.s.i.g. The oxygen rate was measured, utilizing a standard-type flowmeter.

A feed pump having a maximum capacity of 125 g.p.m. pumped the settled sewage to the pilot plant

TABLE I.—Typical Sewage Treatment Plant Data, Stamford, Conn.

Year	Raw Sewage							Primary Clarifier Overflow						
	Solids (p.p.m.)				B.O.D., 5-day (p.p.m.)	Nitrogen (p.p.m.)		Solids (p.p.m.)				B.O.D., 5-day (p.p.m.)	Nitrogen (p.p.m.)	
	Total	Fixed	Vol.	Suspended		NH_4	Org.	Total	Fixed	Vol.	Suspended		NH_4	Org.
1944	4,200	3,400	800	190	250	16	21	2,600	2,100	500	78	160	25	17
1946	700	370	330	230	260	16	20	520	330	190	71	130	16	18
1948	750	460	290	180	190	14	22	620	410	210	76	130	9.6	27
1950	3,400	2,900	500	230	260	16	20	2,000	1,700	300	110	140	20	18
1954	1,100	740	360	310	270	26	17	1,100	810	290	98	155	20	16
1956	850	530	320	260	300	23	31	970	720	130	115	120	14	21

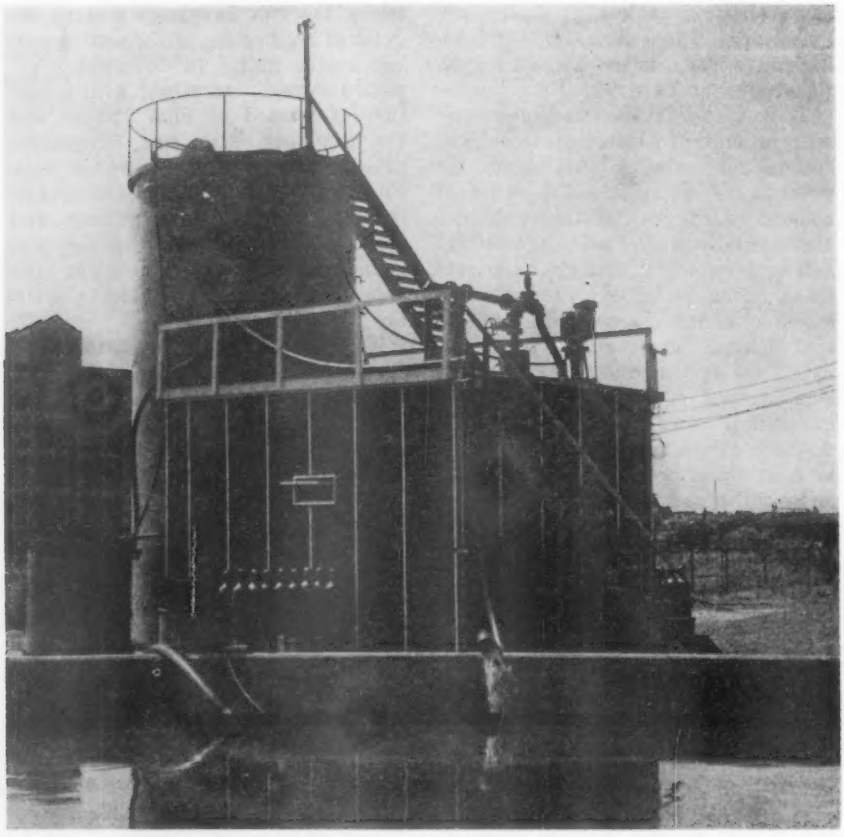

FIGURE 2.—Stamford, Conn., "tonnage" oxygen pilot plant. Note oxygen cylinders and manifold.

through the previously described flow patterns. The pump suction was taken from the main plant primary clarifier effluent just beneath the liquid surface.

To duplicate normal sewage plant operation, facilities were provided to vary the feed to the pilot plant so that it corresponded with the flow variation received at the treatment plant. A flow controller and butterfly valve combination was used to regulate the flow. A cam placed on this flow controller produced an air signal pattern to the butterfly valve corresponding to the flow variations in the plant. This variable air pressure was transmitted to the butterfly valve and caused it to open and close as required, giving a variable feed to the pilot plant.

Wastage of excess sludge from the

TABLE II.—Classification of Data

Series	Flowsheet System	Flow	
		Rate	Volume (g.p.m.)
C_A	B	Constant	40–50
C_B	B	Constant	69–75
V_A	B	Variable	25–70
V_B	A	Variable	30–119
V_C	A	Variable	39–90

TABLE III.—Pilot-Plant Data

Run No.	Date (1956)	Feed "Q" (g.p.m.)	Recycle "R" (g.p.m.)	Sewage Temp. (°C.)	Overflow Rate				Detention (hr.)		B.O.D. (lb.)		Oxygen		Oxygen	Oxygen Utilized		Avg. D.O. Range (p.p.m.)		Series
					Gross		Net													
					(gal./sq. ft./day)	(ft./ hr.)	(gal./sq. ft./day)	(ft./ hr.)	Blanket	Total Tank	Applied per day	Per 1,000 Cu. Ft.*	Feed (lb./ day)	Absorption Efficiency (%)	Feed per M. G. (tons)	Per 1,000 Lb. B.O.D. Applied (tons)	Per 1,000 Lb. Sludge (lb./hr.)	In	Out	
1	1/9–1/15	50	60	12	1,400	7.8	640	3.5	3.0	6.25	73	39	106	56.0	0.74	.41	10.0	0	82.0	C_A
2	1/30–2/5	50	72	12	1,592	8.9	640	3.5	2.9	6.25	104	56	95	61.0	0.60	.28	10.6	1.2	67.0	C_A
3	2/6–2/12	50	80	11	1,720	9.7	640	3.5	3.8	6.25	78	42	109	54.9	0.75	.38	10.0	0.4	63.0	C_A
4	2/13–2/19	45	100	12	1,850	10.3	575	3.2	4.1	7.0	81	44	83	63.6	0.64	.32	9.6	1.1	44.0	C_A
5	2/20–2/26	45	112	11	2,000	11.1	575	3.2	4.0	7.0	67	36	93	65.3	0.73	.45	11.4	1.0	45.0	C_A
6	2/27–3/4	44	104	12	1,890	10.5	560	3.1	6.2	7.2	56	30	92	59.6	0.74	.49	7.4	3.2	43.0	C_A
7	3/5–3/11	69	110	11	2,280	12.7	880	4.9	3.9	4.6	117	63	117	56.1	0.61	.28	9.9	4.1	50.0	C_B
8	3/12–3/18	75	90	11	2,100	11.8	960	5.4	3.5	4.4	106	57	123	64.6	0.56	.37	11.0	3.5	60.0	C_B
9	3/14–3/25	75	100	12	2,240	12.5	960	5.4	3.5	4.4	134	72	120	64.7	0.55	.28	10.4	2.8	64.5	C_B
10	3/26–4/1	75	100	12	2,240	12.5	960	5.4	2.3	4.4	120	65	107	70.1	0.50	.31	13.1	1.1	63.0	C_B
11	4/4–4/10	43	109	12	1,820	10.1	550	3.0	5.6	7.7	70	38	112	38.8	0.88	.31	7.4	0	36.0	V_A
12	4/16–4/22	72	133	13	2,630	14.6	920	5.2	3.7	4.6	99	53	119	37.9	0.57	.23	5.9	0	46.6	V_B
13	4/24–4/30	72	133	13	2,500	13.2	920	5.2	3.7	4.6	123	66	129	41.1	0.62	.22	6.5	0	38.5	V_B
14	4/31–5/6	72	121	14	2,450	13.8	920	5.2	3.7	4.3	109	59	142	43.3	0.68	.53	7.3	0	26.6	V_B
15	5/7–5/13	75	132	15	2,640	14.0	960	5.4	3.6	4.2	116	62	125	37.0	0.58	.20	4.6	0	18.8	V_B
16	5/14–5/20	75	147	15	2,830	16.1	960	5.4	3.6	4.2	120	64	155	41.2	0.72	.27	6.6	0	23.6	V_B
17	5/21–5/27	75	143	18	2,780	15.5	960	5.4	3.4	4.2	139	75	132	57.1	0.61	.27	7.5	1.0	29.0	V_B
18	7/9–7/15	43	185	22	2,940	16.3	550	3.0	3.75	7.4	60	34	72	73.4	0.58	.44	14.1	1.2	23.6	V_A
19	7/16–7/22	43	155	23	2,540	14.2	550	3.0	5.5	7.4	59	33	87	60.0	0.69	.44	8.3	1.5	28.0	V_A
20	7/23–8/29	43	110	24	1,950	10.8	550	3.0	3.7	7.4	66	35	89	83.0	0.52	.55	11.7	3.8	57.1	V_A
21	7/30–8/5	60	125	24	2,360	13.1	760	4.25	1.7	5.3	87	47	122	72.0	0.63	.50	14.2	3.1	66.3	V_C
22	8/6–8/12	60	136	24	2,500	13.8	760	4.25	2.6	5.3	88	47	147	65.0	0.76	.54	14.0	2.8	57.3	V_C
23	8/13–8/19	60	110	24	2,160	12.0	760	4.25	3.1	5.3	88	47	147	62.0	0.76	.52	13.0	Tr.	55.8	V_C
24	8/20–8/26	60	114	24	2,220	12.4	760	4.25	2.1	5.3	89	48	134	60.0	0.69	.45	11.1	Tr.	54.3	V_C

* Runs 1–17, volume based on maximum blanket expansion 19.3 ft. Runs 17–24, volume based on maximum blanket expansion 16.3 ft.

upflow tank was controlled by a timer-actuated pump equipped with a variable speed control for capacity change.

The recirculated flow was pumped by a 50-to 450-g.p.m. unit through the oxygen absorption columns and thence into the upflow tank. Differential pressure orifice meters were used on the discharge side of the recirculation pump and on the settled sewage pump for accurate measurement of the flows.

The pilot plant was operated continuously from May, 1955 to the present time except for periods where process modifications necessitated plant shutdowns. From January through May, 1956, the data were calculated from 8-hr. composite samples collected hourly from 8:00 AM to 5:00 PM. This was the period of highest sewage strength. From June through September, 1956, hourly samples were collected, and composited each 24 hr. When operating on a variable flow pattern, all samples were weighed according to flow. When necessary, samples were iced and maintained at a temperature below 4° C. For convenience in analyzing the data, all data are reported as 7-day averages and classified into various series as shown in Table II. The data collected during this investigation are shown in Tables III and IV.

All analytical determinations were made in accordance with procedures specified in "Standard Methods" (4), except for the analysis of dissolved oxygen during periods when the concentration from the absorption column was extremely high. This departure from standard procedure was necessary due to the difficulties encountered when sampling under pressure.

To overcome the loss of oxygen in solution when exposed to atmospheric pressure a special sampling device was used. It consisted of a stoppered glass jar of known volumetric capacity with two inlets at the top. One of these was connected to a rubber expansion bag and the second was for introduction of the sample to be analyzed. A measured volume of water at a known D.O. content was placed in the jar. A measured amount of the sample to be tested was then allowed to flow under pressure into the volume previously added until it completely filled the sampling jar. The displaced volume caused the expansion bag to inflate and when full all lines were clamped off and the new volume thoroughly mixed. The resultant mixture was then analyzed for dissolved oxygen and the original D.O. content calculated.

Pilot-Plant Operation

Oxygenation Column

In the early stages of operation of the pilot plant, oxygen absorption was performed in three hydraulic countercurrent columns, each 9.5 ft. in height and 12 in., 16 in., and 20 in. in diameter, respectively. The amount of recirculation required determined which one of the three columns was used for oxygen absorption. Generally these columns were designed so that the flow through the column had a high velocity at the entrance and a low velocity at the exit.

Initial design work on this type of column indicated that high absorption efficiencies could be expected. However, it was soon apparent that when this column was operated in series with the upflow unit, successful operation was obtained only within narrow limits. These limits were relative to the liquid velocity and the oxygen feed rate to the column. After experimenting with several modifications one of these columns was equipped with a mechanical mixing unit.

The mechanically equipped unit consisted of a 20-in. diameter column arranged for liquid feed at the top and oxygen feed at the bottom. It contained four 1.5-in. wide, vertical baffles spaced 90° apart and running the entire length of the column.

TABLE IV.—Pilot-Plant Data

Run (No.)	Suspended Solids			5-Day B. O. D.			Sludge Blanket				Load (lb. B.O.D./lb. susp. solids)	Over-all Removal* (%)		Series
	Settled Sewage (p.p.m.)	Final Effluent (p.p.m.)	Removal (%)	Settled Sewage (p.p.m.)	Final Effluent (p.p.m.)	Removal (%)	Depth (ft.)	Susp. Solids (p.p.m.)	Weight (lb.)	Sludge Vol. Index (ml./g.)		Susp. Solids	B.O.D.	
1	119	10	91.5	123	13	89.5	10.8	3,225	246	52	.30	96.0	94.5	C_A
2	135	20	85.5	172	34	80.5	10.4	3,076	227	125	.46	92.5	88.5	C_A
3	97	22	77.0	128	25	83.8	13.5	2,585	248	140	.31	88.5	88.5	C_A
4	138	26	90.8	151	24	83.8	13.3	2,435	228	81	.35	90.5	91.0	C_A
5	125	28	77.5	125	23	81.8	12.9	2,440	222	100	.30	89.0	89.5	C_A
6	125	33	75.0	117	19	84.0	19.3	2,290	311	250	.18	87.2	90.5	C_A
7	123	16	87.0	145	25	83.0	19.3	1,928	263	252	.47	93.5	90.5	C_B†
8	100	18	82.0	119	12	90.0	19.1	2,128	289	267	.36	91.0	94.0	C_B†
9	95	17	82.0	149	21	86.0	19.0	2,222	297	194	.45	91.5	92.0	C_B†
10	88	13	85.0	133	12	91.0	12.3	2,690	234	180	.51	92.5	95.0	C_B†
11	86	16	81.0	137	24	82.5	16.8	2,048	244	168	.29	91.0	90.0	V_A
12	86	53	35.0	119	35	70.7	19.3	2,362	318	139	.33	72.5	84.0	V_B
13	114	73	36.4	145	44	71.8	19.3	2,514	342	138	.36	68.0	83.0	V_B
14	89	47	47.0	126	32	74.6	19.3	2,620	357	123	.31	73.5	85.5	V_B
15	92	42	54.4	127	32	74.9	19.3	3,160	423	102	.27	77.1	85.0	V_B
16	100	33	67.0	132	23	83.0	19.3	2,978	405	90	.30	83.5	90.5	V_B
17	105	51	51.2	154	31	80.0	18.3	3,290	423	76	.33	75.5	88.8	V_B
18	94	17	79.4	117	16	86.2	11.5	1,845	152	72	.47	91.0	92.2	V_A
19	76	21	72.0	114	19	83.0	16.8	2,233	260	65	.24	86.0	90.5	V_A
20	88	26	70.0	128	19	85.0	11.0	3,379	264	66	.25	85.5	91.5	V_A
21	76	47	38.2	121	35	71.0	7.2	4,993	254	74	.34	69.0	83.5	V_C
22	68	25	63.1	123	31	74.5	11.2	3,574	283	88	.31	81.6	85.0	V_C‡
23	66	30	54.6	123	38	77.2	13.2	3,110	291	98	.30	77.2	82.5	V_C‡
24	75	42	44.0	124	38	77.2	8.8	4,834	300	94	.30	72.0	82.5	V_C

* Based on main plant raw sewage strength.
† Sludge recirculated through absorption column.
‡ Industrial waste to plant.

Horizontal baffles were spaced to provide six compartments. In the center of each compartment there was a 6-in. flat-blade turbine propeller connected to a common shaft. The propeller speed was variable, through a motor control unit. Oxygen was introduced at the lower end of the column and rose countercurrent to the downward flow of liquid.

This type of oxygenation column had several advantages over the original unit. It provided greater flexibility of operation and a higher oxygen absorption efficiency. Also the column was independent of the upflow unit over various absorption efficiency ranges for various flows. For a constant rate of flow through the column, various weights of oxygen could be dissolved by changing the combination of the oxygen feed rate and horsepower input to the column. A second advantage was that this method of operation materially decreased the amount of recirculation required. Although the oxygenation column required additional horsepower, compared with the previous columns, the total power for mixing and recirculation was only silghtly more than required originally for dissolving equal weights of oxygen.

Efficiency

Efficiencies in the oxygen absorption column are based on the following determination:

$$\text{Per cent efficiency} = \frac{\text{Weight of oxygen dissolved} \times 100}{\text{Weight of oxygen fed}}$$

After installation of the mechanically equipped column, a series of tests were carried out to determine the column efficiencies so that they could serve as a guide for column operation during the pilot-plant studies. The relationship between power input, oxygen absorption efficiency, and

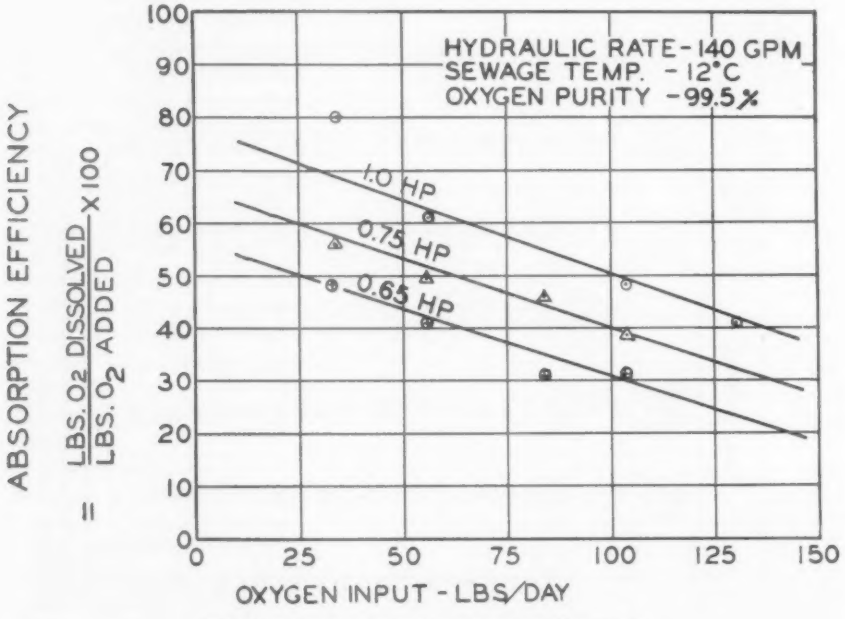

FIGURE 3.—Oxygenation column performance.

the total daily oxygen supplied to the column is shown in Figure 3. The curves and data represented in this figure are based on an average feed rate through the column of 140 g.p.m. at a sewage temperature of 12° C., utilizing oxygen at a purity of 99.5 per cent.

The data tabulated in Tables III and IV were obtained with the application of 1 h.p. to the column for Runs Nos. 1 through 17, and with 3 h.p. for Runs Nos. 18 through 24. The data used in Figure 3 was obtained when a mixture of settled sewage and recirculated flow was passed through the absorption column.

During the course of these pilot-plant studies, it was observed that whenever only treated effluent was recirculated through the column, higher efficiencies resulted than when a mixture of settled sewage and effluent was used. This condition was observed many times and was the reason for changing the point of introduction of settled sewage to a point downstream from the oxygenation step. With this arrangement, the oxygen required by the system was added to the recirculated effluent for transmission to the upflow unit. It is believed that this situation may vary with the type and character of settled sewage. However, further research work will be required to understand the cause of this condition.

Temperature

The temperature of the liquid passing through the oxygenation column also plays an important role in column operation. As the temperature increases, the oxygen saturation level decreases, thus reducing the weight of oxygen that can be put into a given volume of flow. However, this restriction can be overcome by adjusting the rate of recirculation to increase the flow and thereby provide the required amount of oxygen.

Sludge Blanket

After sufficient oxygen had been added to meet the requirements of the settled sewage and sludge blanket, the sewage then entered the main treatment or upflow unit. As the flow carrying the food and oxygen for the organisms must pass up through the blanket, its rate of rise was one determining factor in the total expansion of the blanket.

For any given density in the blanket, the greater the overflow rate or pass-through rate the greater will be the expansion of the blanket. For any constant rate of flow through the upflow unit at a constant density, the blanket volume can be controlled by varying the speed of the submerged rotating arms. The higher the speed of the arms the greater the turbulence and the result is a larger blanket expansion.

With these mechanical and hydraulic methods of control, the next factor to be controlled was the sludge density. Previous experience with the tests at Baltimore indicated that the biological load, in terms of 5-day B.O.D. applied per pound of sludge, must be maintained within fixed limits in order to control the sludge volume index or its settling rate. It was concluded that this B.O.D. loading range would be maintained during the test work at Stamford.

In this system, all of the active sludge to which the B.O.D. load was applied, was carried in the upflow unit. The separation of the sludge from its carrying liquid was performed within this unit; therefore, there was no need for any return of separately settled sludge to the system as in conventional activated sludge practice.

During the course of this investigation, daily samples of the sludge in the upflow unit were collected and analyzed for suspended solids concentration. Based on the concentration and location of the sludge blanket, the

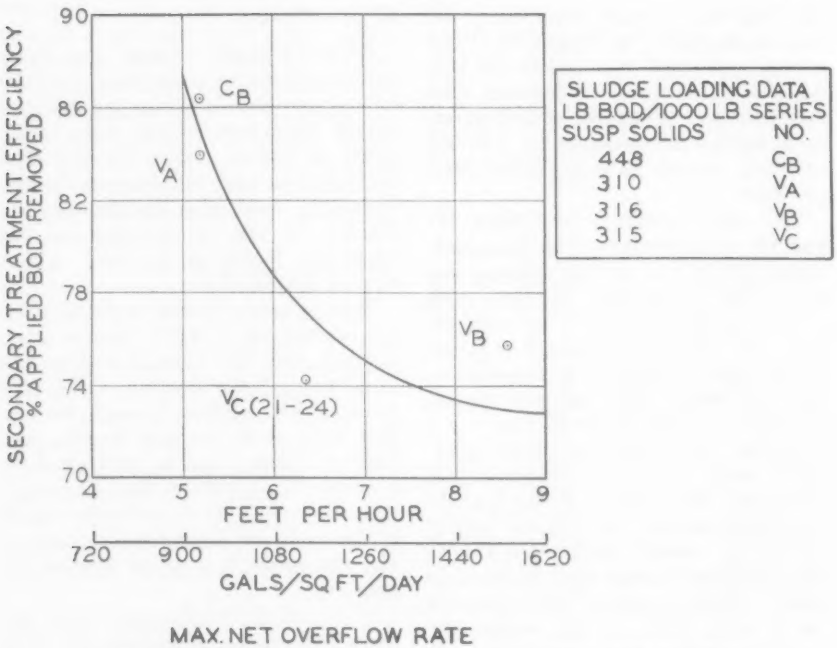

FIGURE 4.—Secondary treatment efficiency versus overflow rate.

weight of sludge in the system was calculated. To maintain optimum B.O.D. loadings, sludge was wasted from the unit until the desired solids concentration was obtained.

Pilot-Plant Results

For a relatively constant biological load and under completely aerobic conditions, the treatment efficiency of this system would appear to be dependent upon two items, namely, time of contact and overflow rate. Overflow rate is in effect inversely porportional to contact time. The greater the throughput rate the less the contact time and the higher the overflow rate.

The relationship between the maximum net overflow rate and the secondary treatment efficiency for the various series is shown in Figure 4. It is to be noted that during these series of runs the biological load varied between 0.18 and 0.5 lb. of B.O.D. per day per pound of suspended solids. The curve in Figure 4 indicates that a maximum net overflow rate of approximately 5 ft. per hour, based on the total square foot area of the tank (900 g.p.d. per square foot), resulted in the best treatment efficiency. Rates lower than 5 ft. per hour did not produce significant increases in treatment efficiency but rates higher than 5 ft. per hour tended to decrease the efficiency of B.O.D. removal.

Application of the load to the biological floc and the method of satisfying the oxygen requirements of the floc in this treatment system are different from those used in the activated sludge process. In this system the biological flocs are loaded continuously. Therefore, the removal of organic material from the sewage proceeds concurrently with its utilization by the microorganisms. The flow entering the bottom of the upflow unit

contains the highest concentration of dissolved oxygen and it is unique with this system that it is applied to the area where the greatest oxygen utilization is found. This is in contrast to conventional activated sludge practice where a uniform amount of air is introduced throughout the length of the aerator, resulting in no dissolved oxygen through the first section where oxygen utilization is greatest.

Oxygen Utilization

The measurements of oxygen utilization were calculated on the basis of the difference between the dissolved oxygen level initially and the level after passage through the blanket of the biologically active floc. The oxygen utilization is recorded in terms of pounds of oxygen utilized per unit weight of sludge per day. To compare this utilization with the rate of biological load, the expression "pounds of B.O.D. per day per 1,000 lb. of sludge per hour of contact" is used to express the loading factor.

Different temperature ranges were encountered throughout these studies; therefore, two oxygen utilization curves were prepared (Figure 5). With increased loading, the rate of oxygen utilization increased from 220 to 280 lb. per day per 1,000 lb. of suspended

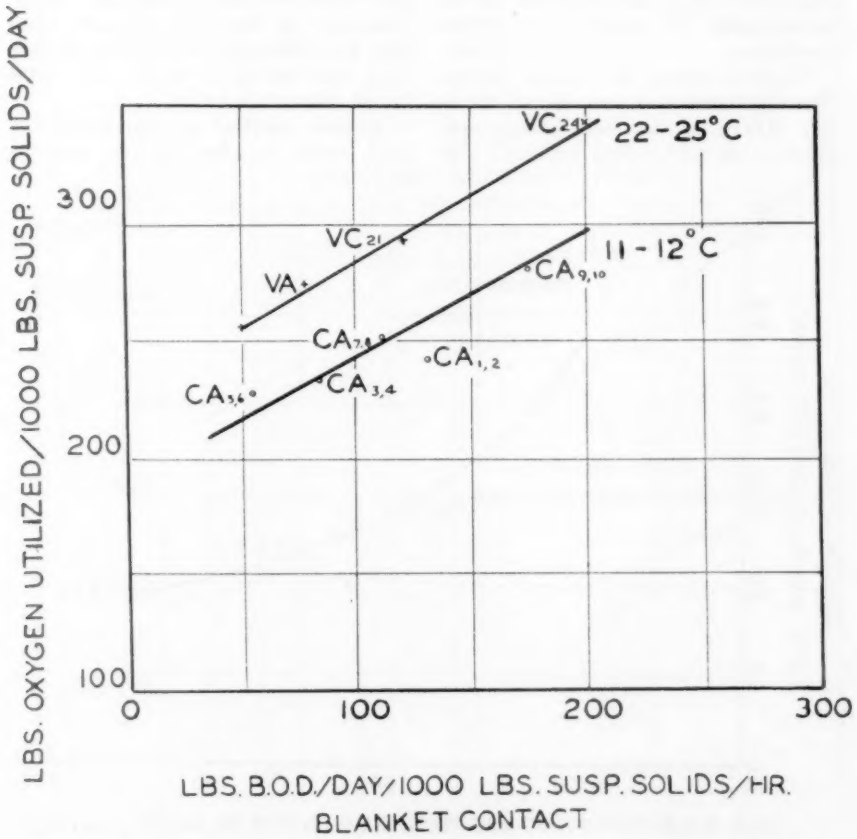

FIGURE 5.—Oxygen utilization curves for temperatures of 11° to 12° C. and 22° to 25° C.

solids (9 to 12 lb. of oxygen per hour per 1,000 lb. of suspended solids) for a temperature range of 11° to 12° C.

For the 22° to 25° C. temperature range, oxygen utilization rates varied between 255 and 340 lb. per day per 1,000 lb. of suspended solids (10.8 to 14.1 lb. of oxygen per hour per 1,000 lb. of suspended solids).

An investigation of the average respiration rates for standard activated sludge revealed a similarity to those determined in these studies. Fair and Geyer (5) report an average rate of 20 p.p.m. per hour per 1,000 p.p.m. of suspended solids. Bloodgood (6) has considered rates of 5 to 20 p.p.m. per hour per 1,000 p.p.m. of suspended solids as sufficient for the maintenance of satisfactory sludge conditions.

Figure 6 shows the oxygen utilization expressed as a per cent of the 5-day B.O.D. of the feed sewage compared with a biological loading. The oxygen utilization decreased from approximately 80 per cent of the 5-day B.O.D. at low load to less than 60 per cent of the 5-day B.O.D. at a high load. This decrease may be attributed to a low degree of B.O.D. removal at the higher loading, as well as a decrease in the amount of oxidation at the higher loading.

Sludge Volume Index and Load

Attempts were made during this test work to maintain the biological load within certain limits for the best settling characteristics of the sludge in terms of sludge volume index. For the greater part of the time the load was in the range of 315 lb. of B.O.D. per 1,000 lb. of suspended solids. However, on the series of runs itemized C_B (Table II and Figure 4), the load was 448 lb. of B.O.D. per 1,000 lb. of suspended solids.

Another method of expressing this load, which is often used in conven-

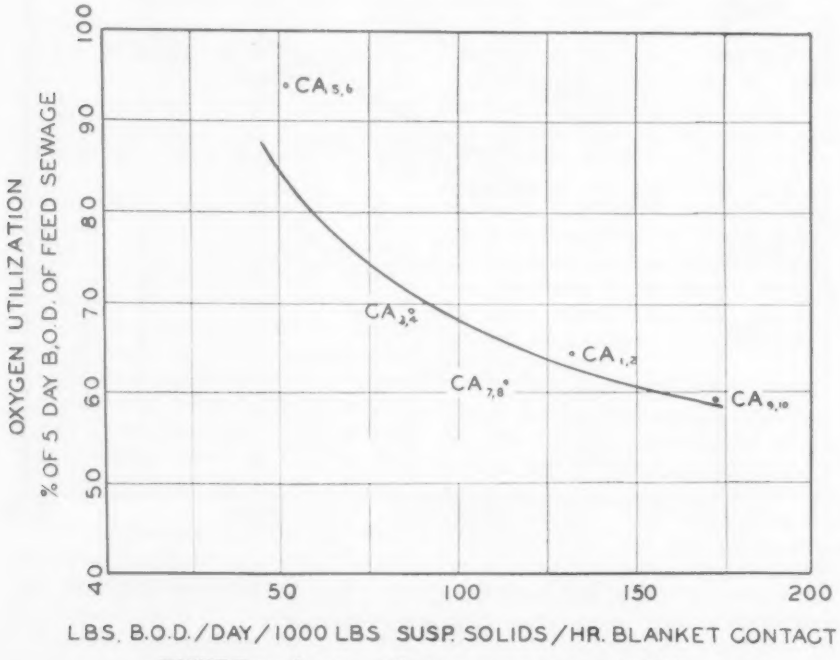

FIGURE 6.—Oxygen utilization versus per cent B.O.D.

tional activated sludge treatment, is in terms of the applied B.O.D. per 1,000 cu. ft. of aeration tank volume. In the aeration studied there is no aeration tank *per se;* therefore, the load per unit volume is expressed somewhat differently. The actual blanket volume in the tank in a sense could be considered as "aerator" volume. However, for the purpose of this paper, if the point of recirculation take-off is considered as the volume parameter, a comparable unit in terms of loading can be developed.

For Runs Nos. 1 through 17 inclusive, the take-off level for recirculation was at a sidewall depth of 19.3 ft. for the main treatment unit. For Runs Nos. 18 through 24 inclusive, this take-off was at 16.3 ft. The average load in terms of pounds of B.O.D. per 1,000 cu. ft. was 64, 35, and 47, respectively, for series C_B, V_A, and V_C, and 63 lb. per 1,000 cu. ft. for series V_B. The B.O.D. reduction performance for this system was comparable with that of conventional activated sludge, up to an overflow rate of 900 gal. per square foot per day.

Comparison with Standard Activated Sludge Practice

A comparison of the requirements of the method of treatment used in the high-purity oxygen pilot plant with the activated sludge process is of interest. Since estimated construction costs vary from one locale to another, and often from engineer to engineer, only area, volume, and operating power requirements were considered in making comparisons.

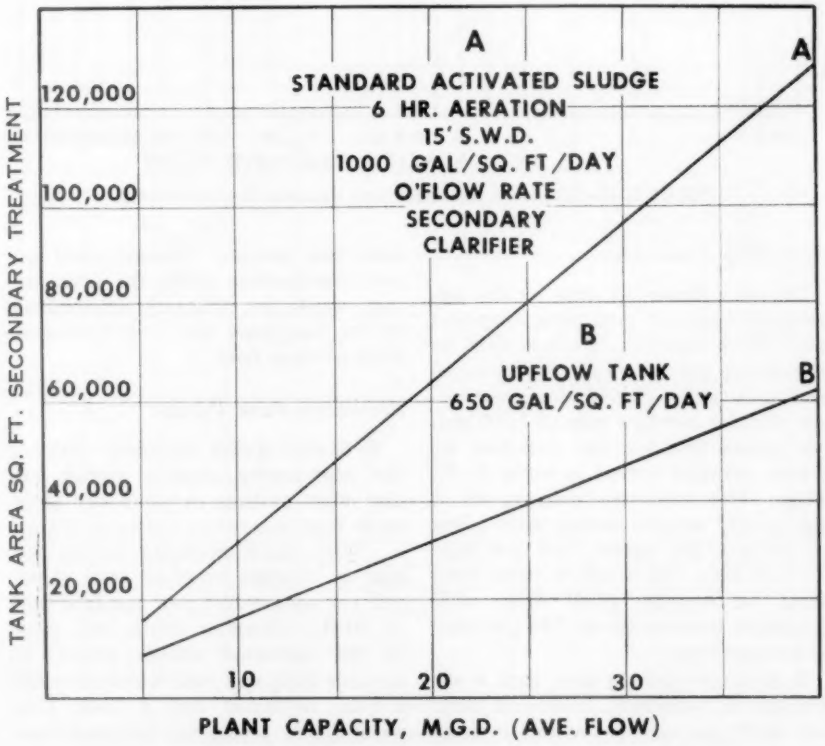

FIGURE 7.—Secondary treatment tank area requirements.

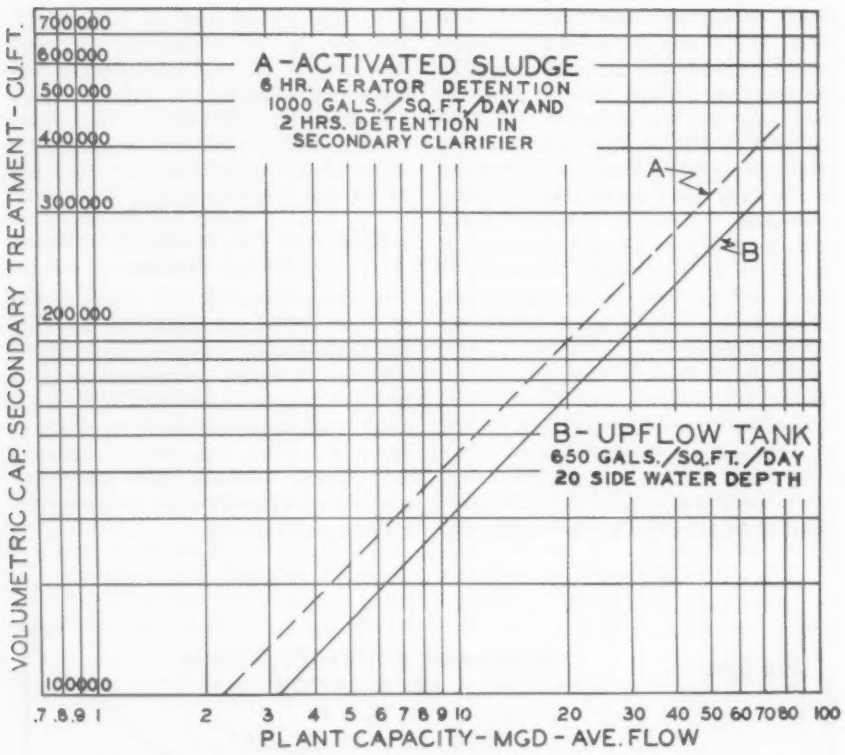

FIGURE 8.—Secondary treatment tank volumetric requirements.

Secondary Tank Area

Figure 7 shows the data for the secondary treatment tank area compared with plant capacity. Factors used in calculating the values for conventional activated sludge provide for a secondary clarifier overflow rate of 1,000 gal. per square foot per day preceded by a 6-hr. aeration period in tanks 15 ft. deep. The area requirements for a high-purity oxygen system were taken as 650 gal. per square foot per day. In each case, the overflow rates were based on average plant flow, with maximum fluctuations of 140 per cent of average flow.

It is interesting to note that a reduction in secondary treatment tank area of 50 per cent is possible even at the lower unit overflow rates used with this system. Should other per cent fluctuations exist, the area savings would be inversely proportional to the maximum per cent fluctuation from average flow.

Secondary Tank Volume

Activated sludge treatment utilizing the high-purity oxygen system can also effect savings in secondary treatment tank volume as shown in Figure 8. With the high-purity oxygen system an average overflow rate of 650 gal. per square foot per day in a tank of 20-ft. sidewater depth was used. In the activated sludge system an aeration tank was used which provided a 6-hr. detention and a 15-ft. sidewater depth. Following this tank there was a 2-hr. final clarifier which had

an overflow rate of 1,000 gal. per square foot per day.

For comparable treatment efficiencies over-all secondary treatment tank volumes can be reduced approximately 30 per cent, resulting in a detention period of 5.5 hr. This is in comparison to conventional activated sludge practice of 8-hr. detention (6-hr. aerator plus 2-hr. final tank).

Horsepower and Oxygen Costs

In order to compare the operating requirements of the two systems of sewage treatment the parameter of operating horsepower versus plant capacity is used. Figure 9 shows this relationship.

Production costs of oxygen are largely dependent on the output volume and vary from $25 to $30 per ton, for a one-ton per day plant, to as low as $7 to $10 per ton, for a 100-ton per day plant. Tonnage costs are essentially affected by quantity and quality. Quantity may dictate the use of low purity oxygen (95 per cent) at lower costs if the volume requirement is sufficiently high. High pressure cycles generate oxygen at pressures exceeding 2,000 p.s.i.g. and at a purity of 99.5 per cent. Conditions often require the use of this cycle.

In the treatment of sewage utilizing pure oxygen, the basic power requirement is associated with the production

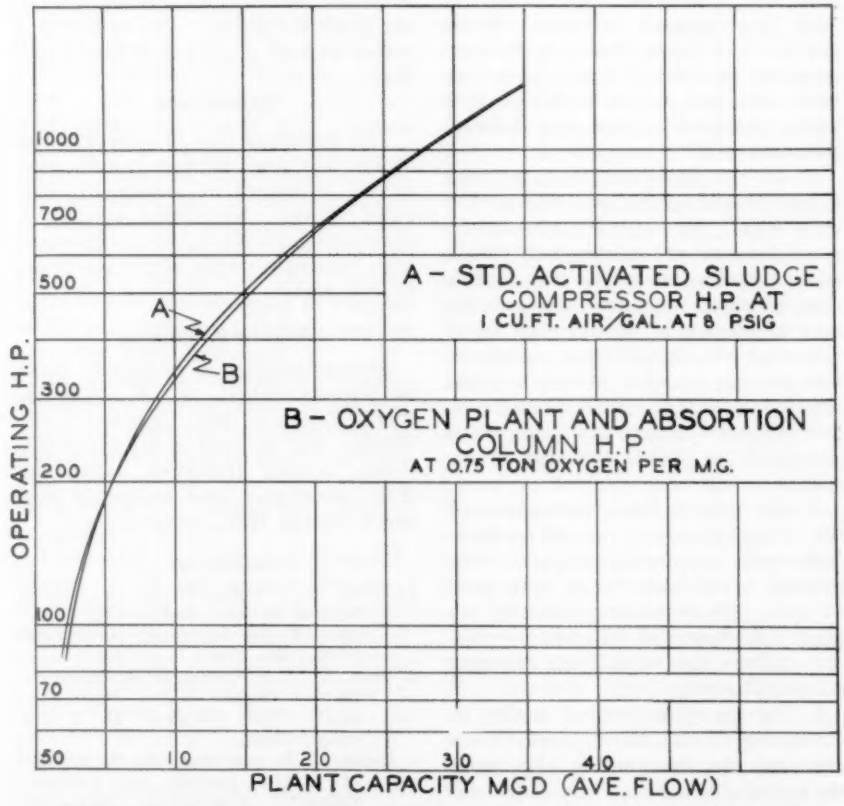

FIGURE 9.—Comparison of power requirements, standard activated sludge and oxygen plant.

of oxygen. However, additional power is also required in the system for oxygen absorption. Similarly, the greatest demand for horsepower in conventional activated sludge systems is in supplying oxygen to the system. The power requirements for conventional activated sludge are based on supplying 1 cu. ft. of air per gallon of sewage at 8 p.s.i.g. The results of this comparison (Figure 9) show that the operating horespower requirements for the two systems are essentially equal.

Summary of Pilot-Plant Results

The results of this investigation may be summarized as follows:

1. The treatment steps associated with conventional activated sludge practice were accomplished by the oxygenation of settled sewage prior to entry into and upflow treatment unit where biological contact and clarification occurred.

2. At the biological loadings used during this investigation (0.18 to 0.50 lb. of B.O.D. per day per pound of suspended solids) the efficiency of B.O.D. removal was a function of the overflow rate, which in turn was related to the time of contact in the system. Overflow rates less than 900 gal. per square foot per day resulted in only a slight increase in B.O.D. removal; however, overflow rates in excess of this value decreased the B.O.D. removal of the system.

3. The total oxygen requirement of the biological system can be economically met by preoxygenation of the influent to the upflow unit with pure oxygen. These studies indicated an oxygen feed rate of 0.75 ton per million gallons for an average strength municipal sewage.

4. The use of mechanical mixing in a countercurrent absorption column provided the best means of oxygen absorption.

5. During a part of this investigation, when pilot-plant flow conditions varied in proportion to the main plant flow, stability and satisfactory treatment efficiency were obtained.

6. For a comparable degree of treatment, a comparison of the results of this investigation with conventional activated sludge practice indicates the following:

(a) Secondary treatment area requirements may be reduced as much as 50 per cent.
(b) Secondary treatment volume requirements may be reduced as much as 30 per cent.
(c) Operating power requirements are essentially the same for both systems.

7. There is no need for the recirculation or return to the system of separately settled sludge. The upflow unit serves as both aerator and final clarifier.

Conclusions

The results of this investigation indicate that pure oxygen can be used in the treatment of sewage by activated sludge. Significant savings in plant size may result, when compared with requirements for conventional activated sludge.

Acknowledgments

Acknowledgment is gratefully made to Superintendent N. W. Wagner, Plant Engineer and Chemist F. Z. Wolden, and the staff of the Stamford, Conn., sewage treatment plant for their cooperation and assistance rendered during this investigation.

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DISCUSSION

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Since the first experimental evidence that sewage treatment by preoxygenation and separate biological floc contact could provide effective waste treatment, there has been considerable interest in the effect of oxygen gas as compared with air on the organisms responsible for biological treatment. Not only has this continuous preoxygenation process been successful, but even fill-and-draw laboratory studies, based on the conventional activated sludge process, have appeared to show superior results when oxygen was used as compared with air (1) (2). The research briefly reported upon herein was designed to help establish the effect of oxygen gas on biological waste treatment.

In addition to offering the possibility of a new, and probably economical, biological waste treatment process, the work reported upon by Budd and Lambeth presents many other new avenues for investigation. Some of these will be discussed further.

Budd and Lambeth, and Robert P. Logan, who worked on the project in its earlier stages, are to be complimented on the unusually fine procedures which they developed and on the thorough investigation of operating results. In its initial development the process was called "bio-precipitation" (1). Budd and Lambeth speak of their plant as an activated sludge unit, although its flow pattern is more like that of a high-rate trickling filter. In general, the term "biological floc" is preferred, regardless of the process.

Experimental Procedure

Three 5-l. jars were set up for oxygenation with (a) oxygen, (b) a commercially-prepared mixture of 60 per cent oxygen and 40 per cent nitrogen, and (c) air. Slow-speed paddles were inserted in the jars to maintain the floc in suspension so that excessive gas would not be required.

Raw domestic sewage was brought into the laboratory, settled, and then added to the jars. The biological floc in each jar was built up without the addition of any other seed material. Twice daily, in the morning and late afternoon or evening, the liquor in the jars was allowed to settle, and 4 l. of supernatant liquor were siphoned off, leaving 1 l. of sludge. Settled raw sewage was then added to bring the liquor in the jars up to the 5-l. mark, and oxygenation and stirring were resumed. The time of settling was reduced from 90 min. in the first series of studies, to 30 min. in the second, and 10 min. in the third series.

The efficiency of treatment was measured by B.O.D. removal after a 2-hr. areation period. In addition to the other routine analyses, the dissolved oxygen content of the mixed liquor was determined polarographically on 2-ml. samples withdrawn at frequent intervals from the jars. In the first two series, the rates of oxygen

utilization were determined polarographically, and the results have been reported elsewhere (2). In the third series, the oxygen utilization rates were determined in a Warburg respirometer, using the gas corresponding to that used in the jars.

Experimental Results

It was found that in the first series, with 90-min. sedimentation, the oxygen-fed unit gave slightly but consistently superior results; with the air-fed unit the results were poorest. When the settling period was reduced to 30 min., the differences were reduced but were still present. Determinations of the dissolved oxygen in the sludge layer indicated that measurable dissolved oxygen disappeared in 24, 16, and 12 min. in the 100, 60, and 20 per cent oxygen-fed units, respectively. It was felt that the periods of zero dissolved oxygen in the latter two units might have been responsible for the poorer efficiency.

Accordingly, a third series was set up with only 10 min. settling. Also to avoid the period of D.O. depletion immediately following addition of fresh sewage, the sewage was preoxygenated. The minimum D.O. values in the mixed liquor, which were reached 15 to 30 min. after addition of the sewage, were about 10, 5, and 1 p.p.m. each in the 100, 60, and 20 per cent oxygen-fed jars, respectively. After 10 hr. of aeration with the various gases, the liquor attained equilibrium values of about 27, 15, and 5 p.p.m. (Figure 10). In this series, it was found that there was no significant differences in the degree of treatment in the three systems.

Oxygen utilization determinations in all three series revealed no differences in rates of utilization, as determined polarographically or manometrically. It was found that the initial rates per unit of volatile solids were higher during the early days of a series, when the volatile solids content in the mixed liquor was low. As the solids built up, the initial rates fell (Figure 11).

In order to test the thesis that the

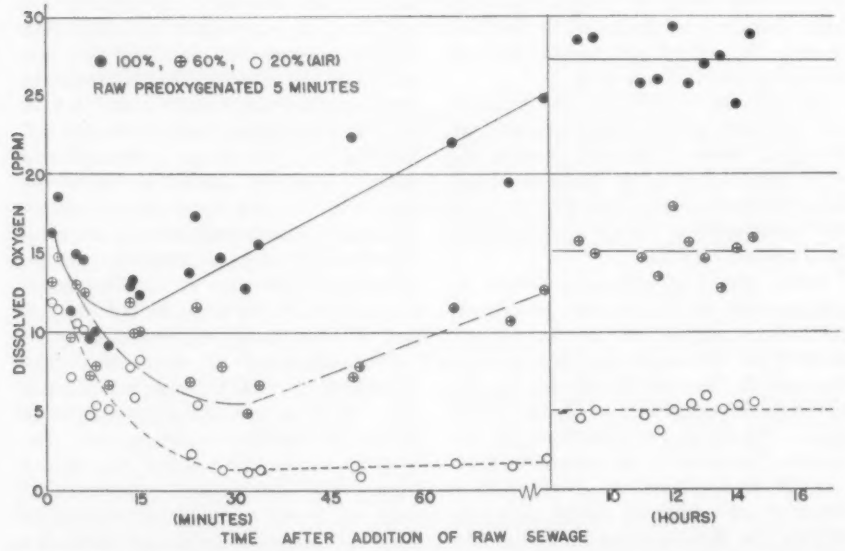

FIGURE 10.—Effect of various oxygen tensions on the D.O. content of activated sludge.

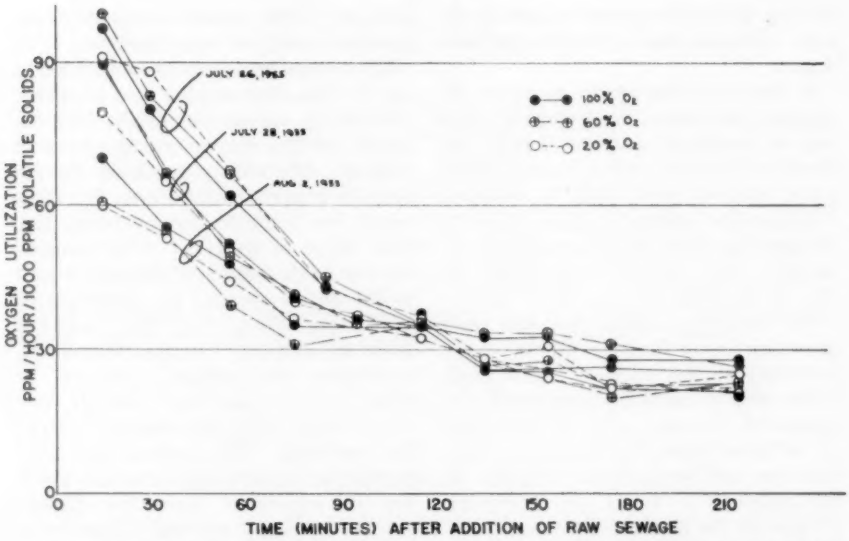

FIGURE 11.—Effect of various oxygen tensions on oxygen utilization of activated sludge.

period of zero dissolved oxygen, which resulted from long settling periods, might be responsible for the varying degrees of treatment, the three jars were fed with pure oxygen, but were settled for periods of 10, 60 and 120 min. No differences were detected. The tests were repeated, using air and settled for periods of 10, 60, and 120 min. The units with settling periods of 60 and 120 min. gave much poorer treatment results than the unit with 10-min. settling. In these tests the sewage was not preoxygenated; therefore, the period of zero dissolved oxygen was considerably longer than the settling period.

Conclusion

From these experiments it was concluded that the higher oxygen concentrations, at levels produced when pure oxygen was used, do not increase the rate of activity of the organisms responsible for biological waste treatment. Oxygen levels attained with air maintained the same activity and efficiency of treatment, provided there was no long period of deprivation of dissolved oxygen.

When air was used, the D.O. concentrations were low. When the sludge settled the D.O. content decreased rapidly and an extensive period without oxygen resources ensued. This permitted some degradation in the quality of the biological floc. The importance of this factor has been recognized in that final settling tanks are designed for rapid removal of activated sludge. However, some damage cannot be avoided completely.

What was unexpected was that long periods of settling, up to 2 hr., did not have a similar effect on the systems using oxygen. When oxygenation was cut off, measurable oxygen was only found for 10 to 15 min. longer than with air. It is hypothesized that the higher oxygen gradient available when oxygen was used might increase the D.O. resources within the floc particles, perhaps even within the cytoplasm of the microorganisms. This oxygen, while not measurable as dissolved oxygen, was available to sustain the floc for a longer period. Perhaps if the

settling period had been extended beyond 120 min., degradation would have begun.

It has long been recognized that the aerobic organisms in biological flocs can be sustained without measurable dissolved oxygen and without calling upon oxidized compounds in solution. Considerable research work needs to be done to establish the mechanics involved. Some of the work should be done with pure cultures.

The aeration process has also been recognized as a limiting factor in the activated sludge process. If a high solids content could be maintained, the treatment efficiency could be increased or the plant could be reduced in size. This has not been possible because of the inability to bring the necessary oxygen to the increased population of organisms. Work using oxygen gas for preoxygenation indicates that aeration has been removed as a limiting factor. One evidence of this is that increasing the level of oxygen does not increase the efficiency.

The advantage of using oxygen does not lie in the higher oxygen concentration attainable, *per se*, but rather in that the higher concentrations permit greater quantities of oxygen to be brought to the organisms. Henry's Law permits a five-fold higher saturation value when oxygen is used as compared with air. In addition, a depth of 20 ft. permits another 50 per cent increase in the oxygen content, so that instead of a saturation value on the order of 10 p.p.m. the saturation values are 75 p.p.m.

If oxygen is no longer a limiting factor, then perhaps the food for the microorganisms is the limit, and the addition of nutrients would increase the efficiency of the process. Or perhaps the end products of the metabolism are limiting and should be removed. These aspects, too, would be fruitful areas for research.

The effect of certain organic wastes might be different from that of plain sewage. This would be another important area for investigation.

There has been considerable interest in the idea that smaller floc particles, created by turbulence, might give superior results due to greater area of contact. The ability to satisfy the increased oxygen requirements for these small floc particles might bring this idea closer to fruition. Their concentration in the bottom of an upflow unit might also overcome the problems of separating these fine floc particles from the effluent. On the other hand, increasing the oxygen gradient by using oxygen gas may provide dissolved oxygen for the centers of large floc particles. Thus oxygen gas may permit the use of large particles which can be separated from the effluent more readily, thereby permitting higher overflow rates. A study of the relationship between floc size and oxygen concentration would also be of considerable research value.

The work at Stamford, Conn., raises another problem—the effect of the nature of the waste on the rate of solution of oxygen gas. Previous experience had indicated that strong settled sewage permitted more rapid solution of oxygen in the oxygenation column than did either dilute settled sewage or biologically treated effluent. At Stamford the recirculated flow, which is virtually the same as the effluent, was much superior in dissolving oxygen than settled sewage. The factors which affect the rate of solution need to be investigated.

Summary

The process using oxygen gas for oxygenation in biological waste treatment offers many possibilities. It also raises many interesting new problems.

One of the problems, the effect of oxygen concentration, was studied. It was found that, if long periods of zero dissolved oxygen were avoided, the level of dissolved oxygen did not

affect the efficiency of treatment nor the rate of activity of the organisms, as measured by rates of oxygen utilization.

Much additional study of process mechanisms needs to be made. It is hoped that the excellent results achieved by Budd and Lambeth will stimulate new researches.

Acknowledgment

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2. Be a graduate of an accredited college of engineering or have proved experience and practice.

3. Be engaged in some aspect of sanitary engineering with at least eight years of satisfactory experience.

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B.O.D. REDUCTION BY CHLORINATION OF PHENOL AND AMINO ACIDS

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The Committee on Sewage Works Practice of the Federation of Sewage and Industrial Wastes Associations published Manual of Practice No. 4, "Chlorination of Sewage and Industrial Wastes" in 1951 (1). From a review of the literature to that time, it was concluded that 1.0 p.p.m. of chlorine produces a reduction of 2.0 p.p.m. or more in the B.O.D. of sewage.

In a laboratory study, Griffin and Chamberlain (2) indicated that the first 35 p.p.m. of chlorine might reduce the B.O.D. of raw sewage by 200 p.p.m. while the next 100 p.p.m. of chlorine gave very little further reduction in the B.O.D. This would indicate that, per unit of chlorine, small doses are much more effective than large doses in the reduction of the B.O.D. The chlorine is much more effective in reducing the B.O.D. in raw sewage than in biologically treated effluents.

Snow (3) indicates that there are both qualitative and quantitative changes in decomposable materials in sewage as a result of chlorination; this is demonstrated by changes in the rates of the B.O.D. reactions. No specific reactions are discussed.

In spite of extensive studies of chlorination, very few experiments on the reactions of specific compounds with chlorine have been published. It is the purpose of this paper to evaluate the relative importance of specific compounds whose chlorination can bring about B.O.D. reductions in sewage.

Theoretical Considerations

The large reduction in the B.O.D. by chlorine is surprising, for the equivalent weight of chlorine is 4.5 times the equivalent weight of oxygen. Thus, on a simple theoretical basis, the reduction in the B.O.D. value of sewage should be 0.23 p.p.m. per 1.0 p.p.m. of chlorine, or approximately one-tenth of the observed reduction. In 1953, Ingols *et al.* (4) showed that chlorination of alanine produces pyruvic acid according to the equation:

$$2\ CH_3CHNH_2COOH_2 + 5\ HOCl \rightarrow 2\ CH_3COCOOH + N_2 + 3\ H_2O + 5\ HCl \quad (1)$$

The ultimate B.O.D. value of alanine requires six atoms of oxygen per molecule while the ultimate B.O.D. value of pyruvic acid will require five atoms of oxygen, as shown in the following equation:

$$2\ CH_3CHNH_2COOH + 6\ O_2 \rightarrow 2\ NH_3 + 6\ CO_2 + 4\ H_2O \quad (2)$$

$$2\ CH_3COCOOH + 5\ O_2 \rightarrow 6\ CO_2 + 4\ H_2O \quad (3)$$

This would indicate that 1.0 p.p.m. of chlorine will reduce the B.O.D. of the alanine by 0.09 p.p.m. or only four per cent of the observed reduction by 1.0 p.p.m. of chlorine in sewage. Since all other common amino acids except glycine have a higher molecular weight than alanine the theoretical reduction

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in the B.O.D. value would be less than four per cent of the observed values.

The removal of the amine group by chlorine results in direct oxidation of the organic compound with no substitution of the chlorine in the by-product. On the other hand, chlorine may react in water to substitute in organic compounds such as phenol even at pH values of 8.0 or 9.0 as evidenced by the development of chlorophenol tastes in drinking water. Thus, phenol plus chlorine readily forms trichlorophenol according to the following equation:

$$3\ HOCl + C_6H_5OH \rightarrow C_6H_2Cl_3OH + 3\ H_2O \ldots (4)$$

The ultimate B.O.D. value of phenol may be represented by the following equation:

$$4\ C_6H_5OH + 28\ O_2 \rightarrow 24\ CO_2 + 12\ H_2O \ldots (5)$$

while the simplest equation for the complete oxidation of trichlorophenol in a B.O.D. test might be represented by the equation:

$$4\ C_6H_2Cl_3OH + 25\ O_2 \rightarrow 24\ CO_2 + 6\ H_2O + 12\ HCl \ldots (6)$$

This equation indicates the rupture of a carbon-chlorine bond for which, as far as the authors know, there is no enzyme system available. It is realized, therefore, that this equation is strictly theoretical and impractical. If, however, these equations are compared, then it can be seen that 1 mg. of chlorine should reduce the oxygen demand by approximately 0.1 mg. of oxygen. Furthermore, it is realized that chlorinated hydrocarbons are used as fungicides. Thus, trichlorophenol is likely to show a much smaller actual B.O.D. value than the possible B.O.D. value of 224 mg. of oxygen. But even a complete reduction in the B.O.D. will require 213 mg. of chlorine or almost 1 mg. of chlorine for the removal of 1 mg. of B.O.D.

Because the theoretical reductions in the B.O.D. of chlorine susceptible organic compounds are so much less than the observed value of the B.O.D. loss in sewage, it was considered of interest to observe the B.O.D. changes in several amino acids and phenol after chlorination.

Methods

The amino acids, alanine, glycine, tyrosine, methionine, valine and aspartic acid, have been used in this study. In all the studies with the dilution technique, the amino acids were dissolved to give a concentration that would result in a theoretical B.O.D. value of 6.0 p.p.m. The chlorinated amino acids were diluted to the same molecular concentration as the original amino acid. The B.O.D. tests of the amino acid and the respective keto acid were prepared with the same seeded dilution water. The chlorination of each amino acid was carried out with an excess of 10 per cent chlorine when compared with the theoretical amount required for the reaction shown in Eq. 1. After a 24-hr. reaction period the excess chlorine was removed by exposing the solution to intense ultraviolet radiation. The residual chlorine had to be less than 0.1 p.p.m., as determined by the starch iodide test before it was diluted 15 times for the B.O.D. test. For each B.O.D. value by the dilution technique, eight replicate individual bottles were prepared and titrated.

In addition to this survey of the amino acids, the intensive study of alanine was made because of its simple structure and the commercial availability of the by-product, sodium pyruvate. The B.O.D. values of the chlorinated alanine and pyruvic acid (supposedly identical) were carefully compared. These comparisons were carried out by both the dilution and respirometer techniques (Warburg or Seirp). A comparison using the dilution technique was made of the B.O.D. value of phenol with commer-

TABLE I.—20-Day B.O.D. Values for Natural and Chlorinated Amino Acids

Amino Acid	B.O.D. (mg./millimole)				Reduction (mg. O_2 per 175 mg. Cl_2 per millimole)		Ratio of Reduction Test Results to Theoretical
	Natural		Chlorinated				
	Theoretical	Actual	Theoretical	Actual	Theoretical	Actual	
Alanine:							
Dilution	96	72.5	80*	23.7	16	48.8	3.06
Warburg	96	73.0	80	2.6	16	70.0	4.37
Glycine	48	65.0	32 or 16	27.5	16 or 32	37.5	2.32
Aspartic acid	96	118.0	80	97.7	16	20.3	1.27
Valine	192	133.0	176	113.3	16	19.7	1.23
Methionine	116	117.0	100	112.0	16	5.0	0.31
Tyrosine	304	202.5	288	108.7	16	93.8	5.87

* This is the value for the B.O.D. of equivalent pyruvic acid. The actual test value was 64 mg. per millimole.

cial trichlorophenol and chlorinated phenol.

Results

A summary of the amino acid data is given in Table I. From the data for valine and aspartic acid, it is evident that the reduction of the B.O.D. values are approximately theoretical. The B.O.D. values in the dilution techniques for the glycine and alanine indicate reductions from chlorination that are several times the theoretical. With the Warburg respirometer technique the residual B.O.D. value of the chlorinated alanine is only three per cent of the theoretical value, but even then 175 mg. of chlorine is required to get a reduction of 70 p.p.m. of B.O.D.

Tyrosine, with its high B.O.D. value in the natural state, has the largest actual drop because of chlorination, as well as the largest ratio of reduction of actual to theoretical.

The B.O.D. value of natural methionine is much less than the theoretical, while the difference in the B.O.D. values for the natural and chlorinated methionine is much smaller than it is for any of the other amino acids tested. The fact that the B.O.D. results for methionine do not agree with the theoretical values has also been shown by

TABLE II.—Comparison of the B.O.D. Values of Phenol and Trichlorophenol

Compounds Added (mg./l.)				B.O.D. (mg./l.)		B.O.D. Reduction by 1.0 mg. Chlorine	
No.	Phenol	Trichloro-phenol*	Chlorine†	3-Day	5-Day	(mg./l.)	Compared to Theoretical
1	10	—	—	3.9	4.7	—	—
2	9	1	—	3.4	4.9	0–0.2	0 to 10×
3	5	5	—	1.9	2.6	0.20	7×
4	0	10	—	−0.4‡	−0.3‡	>0.25	>10×
5	10	—	2.1	2.9	4.0	0.3–0.5	15×
6	10	—	10.5	0.5	1.1	0.35	12×
7	10	—	21	−0.4‡	−0.3‡	>0.25	>8×

* On a molar basis.

† The ratio of chlorine to phenol should give amounts of trichlorophenol in the mixture comparable to the mixtures in Nos. 2, 3, and 4.

‡ The negative B.O.D. values indicate more oxygen remaining than was found in the seeded blanks.

Sawyer (5). Accordingly, the methionine results are not discussed.

A comparison of the B.O.D. values of phenol and trichlorophenol is given in Table II. It may be seen that there is actually a reduction of 50 per cent in a 1:1 molar mixture of phenol and trichlorophenol (commercial material) where a 5 per cent reduction in the B.O.D. might be expected according to theoretical considerations. This would indicate essentially no utilization of the trichlorophenol by the microorganisms. In pure trichlorophenol, the seed exerts less B.O.D. than is exerted by the control. This would indicate a toxic effect by the trichlorophenol on the seed organisms.

Discussion

It has been shown (6) that when chlorine is added to tyrosine, the molecule is altered so that chlorine dioxide cannot react with it to produce color. It was assumed that chlorine was substituted in the phenol ring and thus interfered with the quinoid formation that occurs between chlorine dioxide and tyrosine. From certain unpublished data, it is known that phenol can be readily chlorinated to form 2, 4, 6 trichlorophenol at pH 8.0, and from the data presented in this paper it is evident that trichlorophenol has a much lower B.O.D. value than phenol. By analogy, it can be reasoned that a partially chlorinated phenol ring of the tyrosine would be less readily available biologically than the normal ring. This chlorination of the phenol ring of the tyrosine could explain the large reduction in the B.O.D. of the tyrosine upon chlorination.

From the B.O.D. value of the natural glycine in relation to the theoretical value, it would appear that there was considerable nitrification in the B.O.D. test of the natural acid. When the actual value is reduced with respect to the theoretical value, the B.O.D. reduction caused by chlorinating the glycine approaches the theoretical value. This would indicate that the 28 p.p.m. B.O.D. of the chlorinated glycine is a normal value.

The B.O.D. values for valine and aspartic acid, both natural and chlorinated, agree so well with the theoretical values that they would appear to support the theoretical reactions of Eqs. 1, 2, and 3. In these equations it was shown that chlorinating an amino acid produces the proper keto acid, and that the keto acid uses one less atom of oxygen for the oxidation of each molecule than is used in the oxidation of a molecule of the original amino acid.

The B.O.D. value of the chlorinated alanine has been carefully studied for products other than pyruvic acid in order to explain the large reduction that was obtained. It has been reported (7) that under certain conditions decarboxylation of the pyruvic acid can take place during the chlorination reaction with alanine to produce acetaldehyde. In the presence of an excess of chlorine the acetaldehyde should be oxidized to acetic acid. In this case the odor of vinegar should be distinguished rather than the burnt odor of pyruvic acid; acetic acid has never been detected during the chlorination of alanine with an excess of chlorine. The lanthanum test for acetic acid under the conditions of work performed in this study was negative. Culver and Morris (8) have indicated that chlorine or hypochlorous acid may remove four atoms of hydrogen from glycine under certain conditions with decarboxylation to produce hydrocyanic acid. This reduces the B.O.D. to zero. If a similar reaction occurred with alanine to form acetonitrile, the degree of toxicity of acetonitrile would be important. A few determinations soon showed that acetonitrile is not toxic. This agrees with the work reported by Mills and Stack (9). Acetonitrile apparently does not explain the low B.O.D. value of chlorinated alanine.

The fact that decarboxylation of pyruvic acid may occur during the chlorination of alanine would indicate that side reactions can occur. Easy substitution of chlorine in the methyl group of acetone is well established. A small amount of chlorinated pyruvic acid would greatly reduce the B.O.D. value of the pyruvic acid. Pyruvic acid (commercial sodium pyruvate) can be chlorinated and a small reduction in the B.O.D. can be obtained, but it is not sufficient to equal the B.O.D. value of chlorinated alanine.

In working with the hydrocarbon phenol instead of the amino acids, it can be shown that substitution of chlorine in the benzene ring causes a marked reduction in the B.O.D. The large amount of chlorine required for the formation of trichlorophenol indicates that the trichlorophenol must be very toxic at low concentrations in order to obtain a reduction in the B.O.D. value equal to twice the amount of chlorine added. Certain data indicate that the trichlorophenol is apparently inert in the B.O.D. test rather than toxic, in an equi-molar mixture of phenol and trichlorophenol. Therefore, there is only a small reduction in the B.O.D. value per milligram of chlorine added.

Conclusions

The B.O.D. values of valine and aspartic acid are reduced to approximately the theoretical values by chlorination. Chlorination reduces the B.O.D. values of glycine, alanine and tyrosine in increasing ratios (up to six-fold for the tyrosine) when compared with the theoretical amounts.

The B.O.D. value for phenol is reduced by the formation of trichlorophenol upon chlorinating the phenol at pH 8.0. The trichlorophenol appears to be more inert than toxic.

The data does not show a B.O.D. reduction approaching the average value of 2.0 mg. per liter of B.O.D. per milligram per liter of chlorine, as has been obtained in sewage treatment plant chlorination studies. This may mean that some substance in sewage reacts with chlorine to form a very toxic by-product or that some residual of the chlorine is still present in the sewage samples to interfere with the seed in B.O.D. tests.

Acknowledgment

The nitrogen data were collected by George M. Jacobs in preparation of a thesis submitted in partial fulfillment of the requirements for a master's degree. The phenol data were obtained by Linelle T. Hilley.

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DETERGENT BUILDERS AND B.O.D.

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Although a considerable amount of research has been undertaken concerning the effects of synthetic detergents upon sewage treatment processes, many questions remain unanswered. In the past, interest has centered mainly on the surface-active agent which is considered the active part of the detergent formulation, insofar as cleaning is concerned. However, only 20 to 35 per cent of the detergent is surfactant; the remainder of the formulation consists of a variety of organic and inorganic materials compounded with the surfactant. These materials, which have been given the name "builders," are reported to aid the cleansing action of the surface-active agent. Bogan and Sawyer (1) (2) have described the effects of pure surface-active agents upon the biochemical oxygen demand of sewage. Such data help to a certain extent in predicting the effects a given substance will have on the aerobic biological processes of sewage treatment. This paper reports on an investigation to determine the effects of the common detergent builders on the B.O.D. test.

Materials and Methods

Domestic sewage is a heterogeneous mixture of many substances in varying concentrations; therefore, it was necessary to use a synthetic sewage.

The stock medium was prepared from Difco lactose broth and sterilized according to the manufacturer's directions. A working solution of this medium was prepared fresh each day by diluting 5 ml. of the sterile stock solution to 125 ml. with distilled water. This solution was seeded with 24-hr. settled sewage (1 ml. of seed to 100 ml. of working solution). The 5-day B.O.D. of this synthetic sewage was approximately 350 p.p.m.

Builders Studied

The following detergent builders, all of chemically pure grade, were studied:

1. Sodium tripolyphosphate (Monsanto Chemical Co., St. Louis, Mo.)
2. Sodium hexametaphosphate
3. Sodium phosphate, tribasic
4. Tetrasodium pyrophosphate (Westvaco Chemicals, New York, N. Y.)
5. Versene Fe-3 (Bersworth Chemical Co., Framingham, Mass.)
6. Versene regular
7. Sodium bicarbonate
8. Sodium carbonate
9. Sodium carboxymethylcellulose (E. I. duPont deNemours and Co., Wilmington, Del.)
10. Sodium metasilicate (Pennsylvania Salt Mfg. Co., Philadelphia, Pa.)
11. Sodium silicate (Procter & Gamble Co., Cincinnati, Ohio)
12. Sodium chloride

Standard solutions of these compounds were stored in the refrigerator in order to prevent development of microbial growth.

Laboratory Technique

The standard dilution B.O.D. test (3) was used in this study. The dilutions were prepared in a specially-designed graduated glass cylinder equipped with a convenient draining tube. Exactly 10 ml. of the seeded

synthetic sewage were added to a small volume of dilution water in the cylinder, followed by the desired volume of standard builder solution. The volume was made up to 1,000 ml. and, after thorough mixing, two water-seal B.O.D. bottles were filled. The initial dissolved oxygen content was determined on the first bottle, while the second bottle was incubated at 20° C. for 5 days. On each run, controls were set up in the same way but without the addition of a builder.

The concentrations of builder used in each run were 10, 20, 50, 80, and 100 p.p.m. These concentrations represented the content of builder after the synthetic sewage had been diluted sufficiently to obtain 30 to 70 per cent oxygen depletion in five days. Obviously, these concentrations would represent much higher concentrations in the original undiluted sewage.

Experimental Results

The influence of the test materials on the B.O.D. values of the synthetic sewage is shown graphically in Figures 1 and 2. The data in Figure 1 are plotted as an increase or decrease in the oxygen depletion based on the depletion of the control as 100 per cent. For convenience in plotting, two-cycle semi-logarithmic paper was used, and each curve represents the mean values of five individual runs.

Considering 100 per cent as the base line (*i.e.*, the B.O.D. of the control), a curve with a positive slope indicates an increase in the rate of oxygen depletion. A curve with a negative slope indicates a decrease in the rate of oxygen depletion (B.O.D.). These curves represent relative values since oxygen depletion in per cent of control, resulting from a given increment of builder, will vary with the B.O.D. value of the synthetic sewage. However, use of the standardized synthetic sewage kept the B.O.D. value of the control fairly constant (350 p.p.m., plus or minus 15 per cent).

Nine of the 12 compounds tested influenced the value of the 5-day B.O.D. The exceptions were sodium chloride, sodium bicarbonate and sodium tripolyphosphate, which showed no activity in the concentrations employed. In previous work it was shown that the common builder, sodium sulfate, also is inactive in concentrations up to 100 p.p.m. (4).

Versene regular, Versene Fe-3, and sodium carboxymethylcellulose showed an increase in B.O.D. At the 100 p.p.m. level the two versenes increased

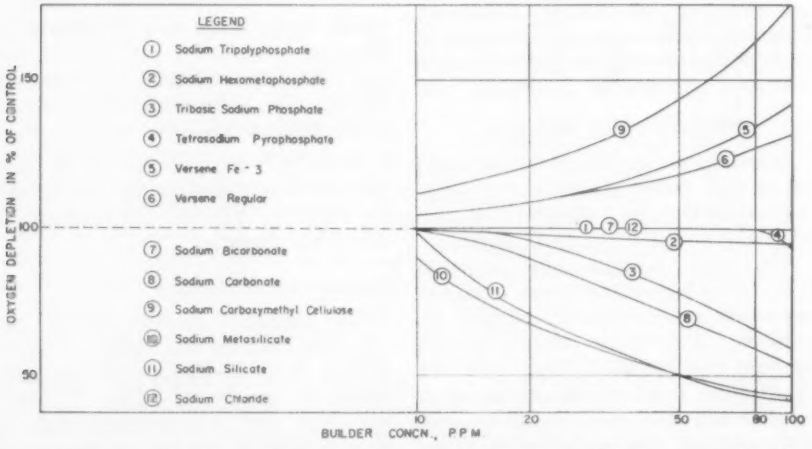

FIGURE 1.—Per cent oxygen depletion due to detergent builders compared with depletion of control.

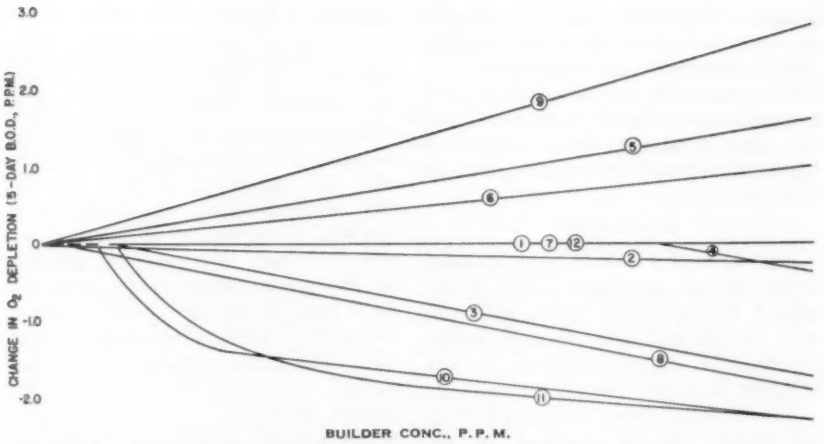

FIGURE 2.—Oxygen depletion resulting from the addition of detergent builders to a seeded synthetic sewage. (For legend see Figure 1.)

the B.O.D. value by about 35 per cent, whereas sodium carboxymethylcellulose was roughly twice as active as the versenes.

The substances producing a decrease in B.O.D., presumably by inhibiting the B.O.D. organisms, included sodium hexametaphosphate, tetrasodium pyrophosphate, sodium carbonate, tribasic sodium phosphate, sodium silicate, and sodium metasilicate. Of these, the first two showed only a slight effect. Tribasic sodium phosphate, and sodium carbonate were considerably more active, whereas sodium silicate and metasilicate were markedly inhibitory.

In Figure 2 the data are plotted as the increase (positive values) or decrease (negative values) in oxygen depletion resulting from added increments of builder. The curves are plotted from points representing the mean of five values, each of which was obtained by subtracting the B.O.D. value of the synthetic sewage (uncorrected for dilution) from the B.O.D. value of the synthetic sewage containing the selected concentration of builder (also uncorrected for dilution). The curve in each case represents that part of the total B.O.D. which is traceable to the builder, *i.e.*, the B.O.D. of the test material.

In most cases, the change in oxygen depletion appears to be a straight-line function of the builder concentration; therefore, the rate of change is the slope of the curve:

$$m = \frac{\Delta y}{\Delta x} = \frac{\text{Change in oxygen depletion (p.p.m.)}}{\text{Builder concentration (p.p.m.)}}$$

The slopes of the lines were determined by calculating the regression coefficient by the method of least

TABLE I.—Rate of Change in Oxygen Depletion and B.O.D. of Detergent Builders

Builder	$\frac{\Delta y}{\Delta x}$	5-Day B.O.D. (p.p.m.)
Sodium tripolyphosphate	0.000	0
Sodium hexametaphosphate	−0.002	—
Sodium phosphate, tribasic	−0.020	—
Tetrasodium pyrophosphate	−0.004	—
Versene Fe-3	0.016	16,000
Versene regular	0.010	10,000
Sodium bicarbonate	0.000	0
Sodium carbonate	−0.017	—
Sodium carboxymethylcellulose	0.028	28,000
Sodium chloride	0.000	0

squares. Where the curves apparently do not represent straight-line relationships, values were not calculated. The B.O.D. value of the stimulatory substances was obtained by multiplying the rate of change by a factor of 1,000,000. These values are given in Table I.

Discussion

Just as in the case of pure surface-active agents, detergent builders exhibited characteristic effects, although none had an iodine demand or caused interference during titration in the Winkler dissolved oxygen method.

A number of these compounds were responsible for an increase in the B.O.D. of the sewage, presumably because they are metabolized by the sewage microorganisms. Another group apparently inhibited the microorganisms responsible for biological oxidation, causing a decrease in the 5-day B.O.D. values.

B.O.D. Activity

A comparison of B.O.D. activity with the chemical structure of the builders is interesting. Those compounds which increased the B.O.D. are essentially organic in nature. Versene regular and Versene Fe-3 are sodium salts of ethylene-diamine-tetra acetic acid, while sodium carboxymethylcellulose is an acetyl derivative of cellulose. All are branched-chain carbon compounds. In addition, the glucose units of cellulose are considered to possess a cyclic configuration. These compounds were metabolized, but showed much lower B.O.D. values than the majority of the surface-active agents (1)(2)(4). A common feature of the surfactant molecule is the long, straight carbon chain. The present observations lend further support to the conclusions of Bogan and Sawyer (1)(2) that the microorganisms can metabolize long carbon chains more readily than cyclic carbon compounds. The data also suggested that branched-chain carbon compounds are attacked less readily than the long chains.

Inhibitory Effects

The inorganic builders were either inhibitory or inactive. Sodium carbonate, sodium phosphate, and sodium metasilicate have been previously established as bacteriostatic or bactericidal, but inhibitory activity in such low concentrations was rather unexpected. However, in no instance was the inhibition 100 per cent complete in the concentration range employed, as it was in the case of the cationic detergent, cetyl-pyridinium chloride (3). The latter compound, at 6 to 8 p.p.m., prevented completely the biological oxidation of the seeded synthetic sewage. The curves for sodium silicate and sodium metasilicate suggest a limiting concentration, beyond which additional builder has no effect. This, in turn, suggests that the compound affects only a limited number of the sewage microflora.

Of the phosphate compounds tested, only the tribasic form caused appreciable inhibition. It had been expected that the three complex phosphates, all sequestering agents, might show considerable activity as a result of this property, possibly by tying up ions essential to bacterial metabolism. However, all the phosphates tried failed to produce significant changes in the B.O.D. value of the sample. It is possible that they become increasingly inhibitory at concentrations greater than 100 p.p.m Furthermore, the type of microorganisms present will probably influence the results. The versenes, which are also complexing agents, were not inhibitory, but this fact is not significant since these materials were probably degraded by the sewage microorganisms.

Significance

Knowledge of the activity of detergent builders independent of surface-active agents has significance because many of the latter are metabolized by the sewage microflora and thus are eliminated entirely or in part. This apparently would leave the builders

free to exert their specific effects. Actually there is little recorded information as to the fate of builders during passage through the sewage treatment plant.

In terms of the B.O.D. test itself, the effects of these materials are relatively insignificant. For example, sodium metasilicate at 20 p.p.m. depressed the B.O.D. by 32 per cent. Assuming a weak sewage with a B.O.D. of 100 p.p.m., it would require a dilution of 1:20 to get a depletion of 30 to 70 per cent. This means that, to have 20 p.p.m. sodium metasilicate in the diluted sewage, there would have to be 400 p.p.m. in the undiluted sewage. This concentration is far beyond the range of builder concentration that would be expected in domestic sewage at the present time, or in the foreseeable future. Estimates made from available data place the present upper limit of total builder content in sewage at approximately 30 p.p.m. Incomplete experimental data indicates a much lower concentration. There is no information on the relative proportions of the various builders in sewage.

In terms of activated sludge or trickling filter treatment, the results are more significant. If 20 p.p.m. sodium metasilicate inhibits biological oxidation in the B.O.D. test bottle by 32 per cent, then it might be reasonable to expect that a constant concentration of this compound at 20 p.p.m. would also inhibit biological oxidation on the trickling filter or in the activated sludge tanks. Whether this is the true situation remains to be determined.

Summary

An investigation of the effects of common detergent builders on the B.O.D. test revealed that, in the concentration range 0 to 100 p.p.m.:

1. None of the compounds tested had an iodine demand or interfered with the Winkler dissolved oxygen technique.

2. The organic type builders, Versene regular, Versene Fe-3, and sodium carboxymethylcellulose, increased the B.O.D. value of the synthetic sewage. It is suggested that this activity is a function of the susceptibility of the chemical structure of the builder molecule to metabolism by the sewage organisms.

3. Six of the inorganic type builders restricted the B.O.D. value of the synthetic sewage to a lower value compared with the control. Listed in order of increasing inhibitory activity, these compounds were sodium hexametaphosphate, tetrasodium pyrophosphate, sodium carbonate, tribasic sodium phosphate, sodium silicate, and sodium metasilicate.

4. Three of the inorganic builders, sodium chloride, sodium bicarbonate, and sodium tripolyphosphate, were inactive.

5. The possible effects of detergent builders on the biological sewage treatment processes must be considered and studied.

Acknowledgment

The authors wish to express their gratitude for the technical assistance rendered by Robert Bostrom.

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Industrial Wastes

CALIFORNIA FRUIT AND VEGETABLE CANNERY WASTE DISPOSAL PRACTICES *

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Fruit and vegetable canning is one of the major sources of income in the State of California. About 15 years ago it was apparent that increasing population would preclude continuation of casual cannery waste disposal practices of the canneries, municipalities, and sanitary districts. In 1949 the state water pollution control authorities established the broad criteria that cannery waste disposal would have to be accomplished without causing (a) damage to fisheries, (b) an odor nuisance or hydrogen sulfide damage, or (c) damage to other beneficial uses of surface or underground waters.

These requirements are being met in all localities of the state, largely by treatment of liquid wastes through public works and by private removal and disposal of solid garbage. The magnitude and seasonal character of this disposal problem introduces unusual needs into the developing of area-wide long range sewerage plans.

Economic Importance

The canning industry owes its birth to Napoleon. The first successful cannery in the United States was located in Baltimore, Md., and the first California cannery apparently was established in 1854 in San Francisco. The industry began to expand during the period 1870 to 1880, when can-making machinery was introduced. Peaches were the first fruit to be canned commercially in California.

The early fruit and vegetable canning plants grew from small local operations and accumulated their capital investments over a period of many years. In general, the amounts invested in production facilities in the industry up until 15 years ago averaged about $1.00 per case of annual production capacity. However, today the increase in construction and equipment costs is such that the replacement value of the plants is approximately $5.00 per case of annual production capacity.

California is unique in the canning of cling peaches and ripe olives. California canners lead in the production of apricots, asparagus, spinach, and tomato products such as paste, puree, and hot sauce. Olive canners produce large quantities of green olives, most of which are shipped in bulk to the East Coast for repackaging. Growth of the fruit and vegetable canning industry in California increased sharply during the rapid population growth of the state in the 1940's. Continued growth in the industry is predicted at the same rate as the population growth of the United States.

Production in the fruit and vegetable canning industry increased more than 400 per cent between 1917 and 1947. Today the industry processes

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more than 3,000,000 tons of fruit and vegetables annually. The quantity of products canned is about as follows:

Product	Quantity (tons)
Peaches, cling	500,000
Pears	190,000
Apricots	50,000
Peaches, free	50,000
Grapes	25,000
Figs	13,000
Cherries	5,000
Plums	2,000
Other fruits	8,000
Subtotal	843,000
Olives	30,000
Citrus	600,000
Tomatoes	1,600,000
Asparagus	40,000
Spinach	20,000
Green beans	5,000
Peas	5,000
Carrots	2,000
Other vegetables	15,000
Subtotal	2,317,000
Total, industry	3,160,000

Canning Industry Centers

Fruit and vegetable canneries are located near the sources of raw products and close to the supply of seasonal labor. Thus all of the 251 California fruit and vegetable canneries are located near or in principal communities of the Sacramento-San Joaquin Valley, around San Francisco Bay, and in Los Angeles and Orange Counties.

Typical Operations

Tomato Cannery

A typical tomato cannery (Figure 1) in the median production range will process about 50 tons of tomatoes per hour into solid pack tomatoes along with some combination of tomatoes in puree, tomato juice, catsup, tomato sauce, and tomato paste. This operation lasts for 60 to 75 days in a normal season; during all or part of the time the plant operates two shifts per day. Water used in the packing operation amounts to about 3,300 g.p.m.

Tomatoes are delivered to the plant from the fields in lug boxes and dumped into soak tanks. Clean water is constantly being added to the soak tanks to replace the overflow which carries leaves, dirt, and microorganisms washed from the tomatoes. After the tomatoes have been carried through the soak tank, they are sprayed with fresh water under considerable pressure, to cut out and wash away portions of the tomato which have been softened. Unsound portions of the tomato are then cut out by hand and handled as garbage. The sound portions of the tomatoes which have been trimmed are used in standard pack tomatoes or for some comminuted products.

Tomatoes selected for canning purposes are next passed through the scalder where they are subjected to steam or boiling water, or are put through a flame peeler. The peeled and cored tomatoes are transferred to the canning tables and packed in cans, which remain unsealed while they are passed through the exhaust box.

After exhausting, the cans are closed and processed at a minimum temperature of 212° F. It is important that the cans then be cooled quickly and uniformly.

The processing of tomatoes for puree, sauce, paste, and catsup is carried out in a similar manner to canning tomatoes, up through the peeling step. After peeling, the tomatoes are run through a pulper. The mechanism customarily used forces the fluid and pulp cells through a fine screen, thus giving a suspension of finely divided pulp. The seeds, skins, and coarse fibre particles are separated and diverted to waste flows where they are recovered for livestock feed. The pulp is then concentrated, either in open kettles or under vacuum. The final step is cooling of the cans with water.

Tomato juice preparation involves the usual preliminary steps of washing, inspection and trimming, and scalding. Thereafter, the tomatoes are given a light pressing. Probably the most common practice in California

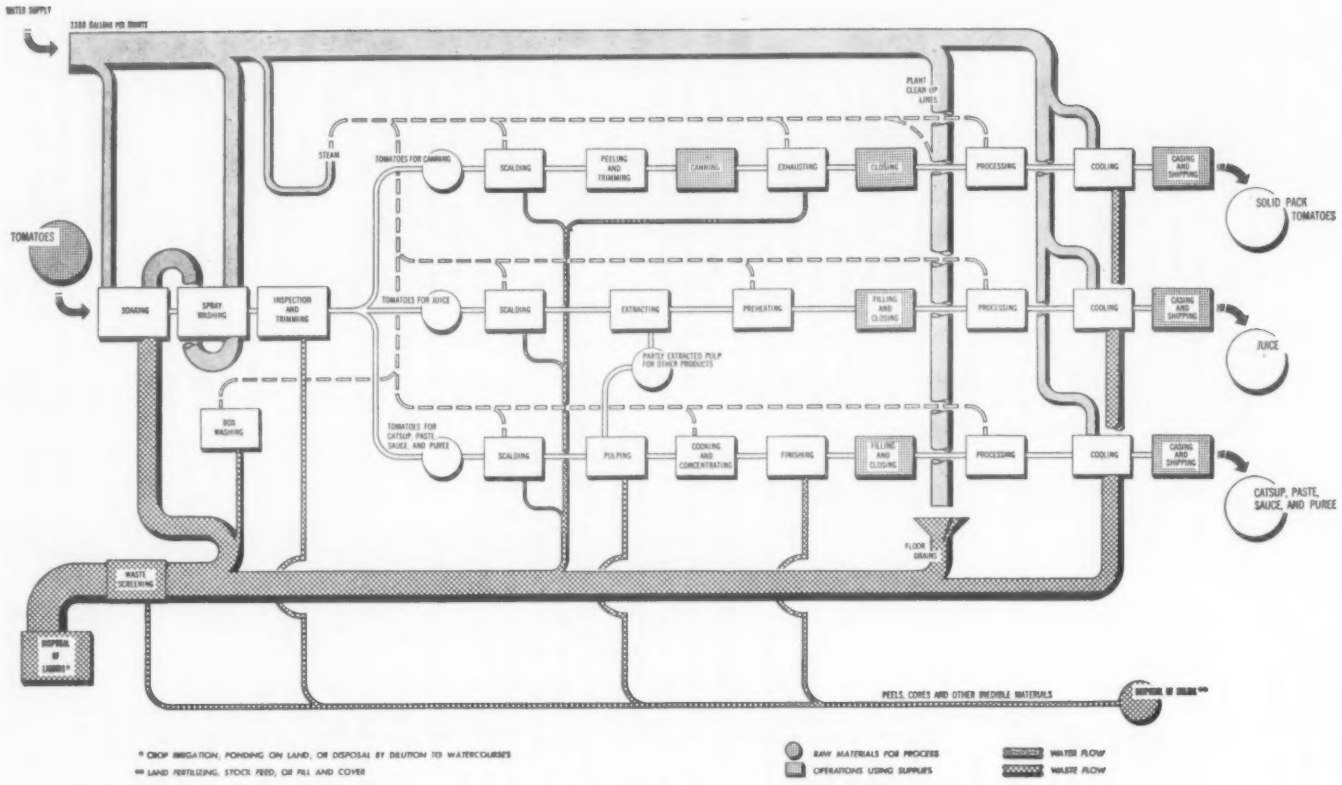

FIGURE 1.—Water uses and sources of wastes in a typical tomato cannery.

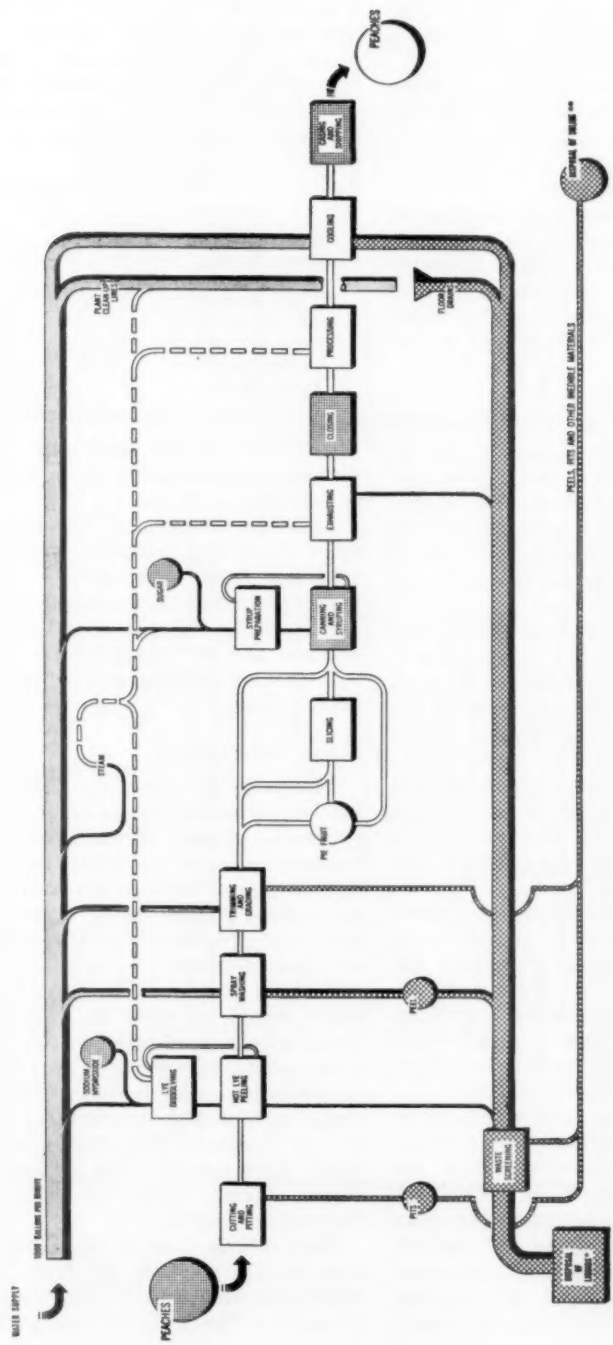

FIGURE 2.—Water uses and sources of wastes in a typical peach cannery.

canneries is the preheating of the juice, filling and closing of the cans, and processing at 212° F.

The cans are then water-cooled by spraying or immersion. The partially-extracted pulp from the juicing operation is used in the manufacture of other tomato products.

A very important operation in the processing of tomatoes is the washing of the field boxes. This is necessary to prevent the development of a heavy load of microorganisms and possible spoilage of tomatoes enroute to the cannery.

Peach Processing

A typical peach cannery (Figure 2) near the median position in output will process about 25 tons of peaches per hour. This operation lasts 35 to 40 days in a normal season; during all or part of the time the cannery operates two shifts per day.

Peaches are received at the cannery in lug boxes. The first operation is to cut them in half and remove the pits. The halves are belt-conveyed to the peeler, where they are treated with a dilute hot lye solution. The system is usually cleaned and a new solution of lye is made up at the end of each shift. At that time the spent lye is discharged to the sewers and the peeler is cleaned.

After the lye treatment, the peaches are subjected to water sprays under considerable pressure to remove the skins and excess lye. During the operations of sorting, trimming, grading, and slicing, the fruit is usually handled under water sprays to insure cleanliness and protect quality.

The peaches are next conveyed on belts to the canning department, where, after further inspection, they are placed in cans by hand. The cans are carried along a belt to the automatic syruping machine and through an exhaust box, where air is eliminated from the contents and the temperature is increased by means of steam. The cans are then closed, processed, and cooled with large quantities of water. Cooling is necessary to maintain the quality and nutritional value.

The waste flows from major wet operations in peach canning are as follows:

Operation	Waste Flow (gal. per ton of peaches)
Lye peeling	50
Spray washing	360
Sorting, grading, slicing, and canning	120
Exhausting	50
Processing	25
Cooling cans	950
Plant cleanup	845
Total	2,400

The B.O.D. of the untreated waste averages approximately 30 lb. per ton of peaches.

Although the canning operations of other fruits and vegetables vary considerably from those shown on the peach processing flow diagram (Figure 2), major water uses and sources of waste flow are commonly associated with product washing, can cooling and plant cleanup.

Citrus Processing

Processing of citrus in California has lagged behind that in other citrus-producing states. In the 1930's this industry began to grow and by 1946, 328,000 tons of citrus fruits were used for canning purposes alone. California has a virtual monopoly on the canning of lemon products.

Portions of the various citrus fruits which would normally be wasted, as far as other canned fruit or fruit juice is concerned, have found a wide range of utilization as by-products. The average medium-size cannery (Figure 3) will process 20 tons of oranges per hour. This operation has an 8-month season, during which two shifts per day may be worked.

When citrus juice is produced, the first step is to wash the fruit with detergents and considerable volumes of water. The fruit is then graded,

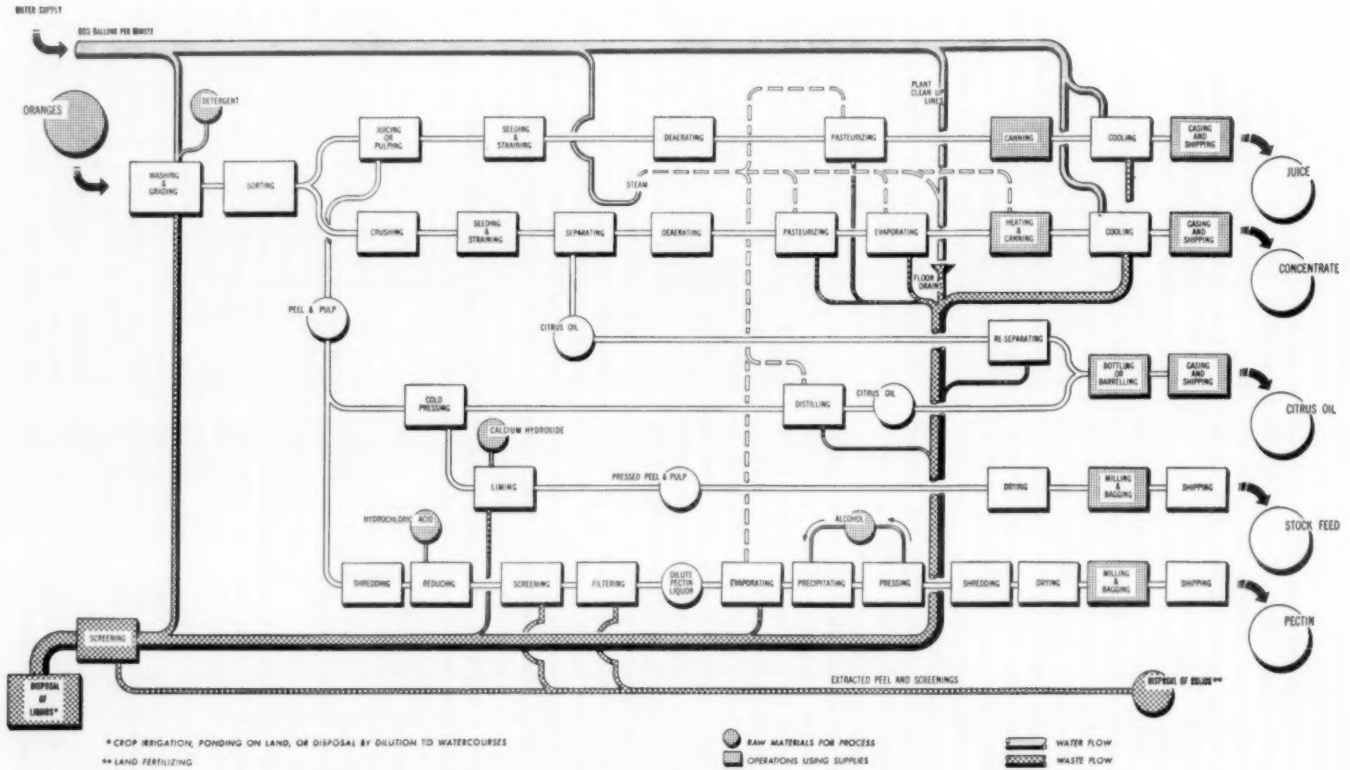

FIGURE 3.—Water uses and sources of wastes in a typical citrus cannery.

trimmed and sorted, prior to juicing. After the fruit has been juiced, the peel and pulp are diverted for other by-product use. The juice is strained, deaerated, and pasteurized, and the cans cooled immediately with large quantities of water.

In the manufacture of concentrates, peel and pulp are diverted after the juicing operation for further processing. After the seeds are removed from the juice, it is passed through a centrifugal separator for removal of the citrus oil. The juice is then deaerated, pasteurized, and evaporated in vacuum pans.

Citrus oil obtained by centrifuging the juice of crushed fruit is passed through a second centrifuging process for more complete purification.

Citrus oil also is obtained by means of further pressing of the peel and pulp resulting from any one of the juicing methods. The oil is purified by distillation and then bottled or barreled. The peel and pulp residue from this cold-pressing process is customarily dried, milled and bagged for livestock feed.

If not used as the source of citrus oil, the peel and pulp may be treated to recover the pectin. The peel and pulp are first shredded and then treated or reduced with dilute hydrochloric acid. Dilute pectin liquor is separated by means of screening and filtration, prior to concentration by evaporation. Pectin is first precipitated by treatment with alcohol, and then it is pressed, shredded, dried, and finally milled and bagged.

Waste Disposal Needs

In most industries, solid and liquid wastes are incidental to or a result of processing losses. In fruit and vegetable canning, the wastes consist of the peelings, pits, cores, and other inedible portions of fruits and vegetables, which are equivalent to kitchen garbage. As in the home kitchen, adequate washing in suitable water and disposal of inedible portions constitute important steps in the handling of these products. Liquid wastes from fruit and vegetable canning consist mainly of the large volumes of water which are necessary for (a) washing the product, (b) plant sanitation, (c) sanitary transfer of cleaned and prepared food throughout the plant by fluming, and (d) cooling of the cans.

The principal difference between cannery and kitchen operations is to be found in the seasonal character of

TABLE I.—Analysis of Typical California Cannery Operating Practice

Product	Raw Tonnage Processed (tons)		Canning Days, 16-hr. (No.)	Seasonal Case Production*	Water Use		Garbage†			Waste Flow Suspended Solids Conc. (p.p.m.)
	Per Hour	Season			Per Raw Ton (gal.)	Season (million gal.)	Total Tonnage (tons)	Per Cent Discharged to Sewers	Discharged in Typical Waste Flow (tons)	
Peaches	25	16,000	40	687,500	2,400	38.4	3,500	21	750	700
Apricots	25	10,000	25	550,000	2,400	24.0	900	22	200	300
Asparagus	10	4,000	25	192,000	6,500	26.0	2,600	1	30	35
Pears	20	3,200	10	121,500	1,500	4.8	1,500	10	150	1,040
Spinach	10	3,200	20	128,000	7,500	24.0	1,120	12	130	180
Tomatoes	40	22,400	35	785,000	4,000	89.6	5,200	26	1,350	450
Total	—	58,800	155	2,464,000	—	206.0	14,820	—	2,610	—
Avg.	—	—	—	—	—	—	—	17.5	—	450

* 24 No. 2½ cans per case.
† Also settleable solids.

cannery operations, which results in periodic pyramiding of waste loadings.

Table I shows water use, waste flow, and garbage quantities for a typical California cannery. Consumption of 206,000,000 gal. of water during 155 days of operation represents a water use of 1.33 m.g.d., but the average use rate occurring during the tomato season is 3.84 m.g.d. Discharge of 2,500 tons of garbage and washings results in approximately 500 p.p.m. suspended solids in the 200,000,000 gal. flow. A waste flow strength of 500 p.p.m. suspended solids will be exceeded unless the cannery is equipped with screening equipment. Screening is not generally used to assure a suspended solids content of less than 500 p.p.m.

Garbage Disposal

Costs for food processing plant waste disposal include the handling of solid garbage, as well as liquid wastes. The choice of method for disposing of solids is made after comparing the costs of the following methods:

1. Costs for disposing of all garbage directly from the cannery to land, or for processing and recovery as meal.
2. Costs for disposing of varying amounts of the garbage by dumping and handling the remaining amounts as suspended solids in the waste flow discharged to the sewers.

There is some disposal of peels, pits, cores, and such other inedible materials via recovery of pit by-products, sugar or nitrogenous materials, and livestock feed. However, the bulk of this type of garbage from fruit and vegetable canning is trucked to dumps, used for hog feeding, or spread on agricultural land.

In "cut and fill" disposal, the soil is removed and the garbage is placed in the resulting trench or excavation and then covered with the original soil. The success of this type of disposal program depends on availability of adequate areas with the proper type of soil and drainage, located at reasonable haul distances from the canneries. If the region is well developed agriculturally, or a part of an urban center, it may be difficult to find such locations. The spreading of cannery garbage on agricultural land is used for disposal of large quantities of solid wastes in the San Jose-Santa Clara-Sunnyvale area.

Special procedures have been developed by a scavenger company for disposal of garbage from canneries located between Berkeley and Hayward. The dump site is on 120 acres of bay bottom, reclaimed within a semi-circular 15-ft. high levee. Year-round collection of community garbage and refuse is placed in fills 20 ft. deep, which are 100 ft. or more in width and parallel to the levee.

Before the canning season starts, mud is excavated from basins parallel to and alongside the garbage and refuse fill. This excavated material is piled 12 to 15 ft. high around the basins to construct a series of cells about 75 ft. wide and from 75 to 150 ft. long. Each cell is drained through its own screened outlet structure to a collection ditch which discharges the "press liquor" to disposal by dilution through an outfall into San Francisco Bay. Each cell is designed to be filled in from 7 to 10 days. When the first cell is filled and dumping started in a second cell, an 8- to 10-ft. cover of community garbage and refuse is placed over the cannery waste. Thereafter, the top of the combined fill is covered with imported quarry wastes.

During the peak of the 1956 season more than 1,200 tons of cannery garbage per day were received at this operation. For several weeks the total of garbage and trash collections from a population of 1,000,000 was not sufficient to provide prompt cover of the cells. This procedure can be used only where the supply of community

TABLE II.—Liquid Cannery Waste Disposal Practices

Area	Raw Tonnage Processed (tons)	Treatment		Disposal		
		Private	Public	Land	River or Bay	Ocean
Central Valley	1,250,000	11	66	9	68	—
San Francisco Bay and North Coast	1,250,000	40	44	54	40	—
Central Coast	60,000	5	8	5	4	4
South Coast and Colorado River	600,000	19	58	21	5	51
Total	3,160,000	75	176	89	117	55

garbage and refuse is adequate for an 8- to 10-ft. cover on a day-to-day basis.

Much study has been given to organic by-product manufacture from cannery wastes by individual canners, the National Canners Association, the U. S. Department of Agricultural Regional Laboratories, and other research groups. However, the results have had little practical value in adding to established marginal uses of these wastes.

Liquid Wastes Disposal

The canning industry and municipalities, under California conditions, can consider one of the following methods for the final disposal of liquid fruit and vegetable processing wastes:

1. Dilution in a river or tidal flow after minimum treatment.
2. Dilution after sufficient primary and secondary treatment to permit discharge to an otherwise insufficient river or tidal flow.
3. Spreading on an adequate acreage of well-isolated land, or lagooning after minimum treatment, for percolation, evaporation, or release when sufficient dilution is available.

Ponds or lagoons to which sodium nitrate is added for secondary or complete treatment of cannery waste, are of limited practicability in California because of the large volumes of waste. Activated sludge and biological filtration processes are not well adapted to disposal of cannery wastes during the short canning season, because these biological processes are not adaptable to sudden loading. In addition, especially in the case of fruit wastes, the acidity of the waste, the relatively high sugar content, and the lack of proteins combine to preclude the use of conventional secondary treatment.

Table II gives data on the disposal practices for liquid cannery wastes in the principal cannery areas in California.

The privately managed liquid waste handling operations account for most of the land disposal. As population pressures increase it will be practically impossible to hold sufficient acreage near communities for the purpose of isolating the lagoon or providing a spreading area for nuisance-free treatment of large flows.

The delta section of the Central Valley watershed, is primarily concerned with the protection of fish life and the preservation of the river water for industrial use and limited recreation. In this watershed 26 of the 44 canneries discharge their cannery wastes to sewers operated by governmental agencies. The waste from 31 canneries reaches the rivers or sloughs. Of the 13 canneries whose waste is spread on land, 10 operate their own disposal facilities. It appears that the responsibility for final disposal of industrial waste in this area will rest with municipalities and sanitation districts.

In the Southern San Francisco Bay Section there is a dense concentration

both of population and of canneries which precludes private disposal practices by the industry, and offshore disposal results in extensive sludge deposits on mud flat areas when there is a shortage of dilution water. The fruit and vegetable canners in this area must depend on municipal sewerage systems for industrial waste disposal services and accordingly are required to pay considerable in sewer rental charges.

In the arid, but densely populated southwestern portion of the state, attention is directed toward prevention of pollution of underground waters and bathing beaches, and toward area projects for disposing of sewage and industrial wastes by dilution in the ocean.

The industrial wastes originating from 32 of the 41 canneries located in this area are discharged to sewers operated by governmental agencies. Twenty-seven of these canneries discharge to sewers of either the City of Los Angeles or the county sanitation districts.

Green-Ton Equivalent

The distinction between cannery and sanitary wastes has created specific terminology for area-to-area comparison of cannery waste problems. The term "population equivalent," which has been used as a measure of quantity of cannery wastes, fails to provide attention to the seasonal fluctuations in quantity of these wastes.

The waste from processing one ton of a particular fruit or vegetable for canning has a fixed relationship to the waste from processing a ton of another fruit of vegetable. For example, the total amount of oxygen required to stabilize the waste from one ton of raw spinach has a definite relationship to the oxygen requirements from processing one ton of olives.

To establish these relationships, the total tonnage of each major product canned in California has been multiplied by presently available values as to the number of pounds of oxygen required to stabilize the usual amounts of untreated liquid waste which result from processing a ton of the particular product. These results have been totaled and then divided by the total number of tons of all green fruits and vegetables used for canning. This quotient is considered the oxygen requirement of the "average green ton." The B.O.D. value of the untreated waste from a green ton of any product under consideration, divided by the oxygen requirement per average green ton, gives the "green-ton equivalents" for the untreated effluent from processing a ton of the product. This relationship can be stated as:

$$\frac{\text{B.O.D. in pounds for total tonnage of all products}}{\text{Total raw tonnage of all products}} = \text{Oxygen requirement per average green ton}$$

$$\frac{\text{B.O.D. in pounds per ton of product in question}}{\text{Oxygen requirement per average green ton}} = \text{Green-ton equivalents}$$

Seasonal Peaks

Comparison of the various processes indicates a wide range in amounts of waste produced. Considerable variation occurs in volume produced by the different steps in a process, as well as variation in the inorganic and organic chemical composition of the individual waste flows. The period over which a cannery is producing waste from a given fruit or vegetable is usually brief. The seasonal spread in the wastes resulting from canning reaches a peak in September. The usual effect is that operating difficulties occur at municipal treatment works during

August, September, and October. The effects of these difficulties on sludge digestion carry through to December. This peak loading coincides with periods when there is a minimum quantity of water available for dilution and when atmospheric conditions favor the development of odor nuisances. Seasonal variation in waste disposal needs of the canning industry results in low cannery waste treatment works use factors.

Water Re-Use

Directly connected with waste disposal is the problem of water re-use. Many persons have advocated water re-use as a readily available, partial solution for problems of waste disposal, as well as for water shortages.

Re-use of water introduces processing problems, principally those associated with the rapid multiplication of microorganisms. One of the principal dangers is the possibility of product spoilage when water from cooling cans is re-used without being heavily chlorinated. Water from can coolers may be safely used for washing raw fruit or vegetables in immersion washers which are followed by spray washers, but water from the first washers should not be re-used. Only fresh water should be used for final washing of the product. Warm wash water should not be re-used because the bacterial count increases rapidly, and incipient spoilage may occur in the food before processing owing to this contamination.

Public Waste Treatment Works

The variety of situations and problems encountered by municipalities and sanitary districts is evident from comparison of data in Table III for off-season and canning season flows and strengths where canneries are using public works for treatment and disposal of their liquid wastes.

No problem is encountered at Sacramento where adequate treatment is provided in a primary treatment plant for ultimate disposal by dilution in the large flow of the Sacramento River. This is made possible by the high per capita water use of more than 350 g.p.d., which provides for a dilute industrial waste. Conversely at Stockton, Modesto and Turlock the available river flows are insufficient for

TABLE III.—Comparison of Off Season *vs.* Canning Season Municipal Sewage Flows*

Plants (California)	Flows (m.g.d.)		B. O. D. (p.p.m.)		Suspended Solids (p.p.m.)		Treatment and Effluent Disposal
	Off-Season	Canning Season	Off-Season	Canning Season	Off-Season	Canning Season	
Sacramento	48	56	180	400	130	190	Primary, ample dilution, Sacramento River
Stockton	12	18	400	1,700	350	450	Primary-secondary, limited dilution, San Joaquin River
Modesto	2.5	15	200	1,000	200	250	Primary-secondary, limited dilution, Tuolumne River
Turlock	0.2	4.8	300	1,500	300	350	Primary-secondary, limited dilution, irrigation ditch
San Jose	20	35	400	900	300	550	Primary, limited dilution, Southern San Francisco Bay
Hayward	3.2	7.0	250	1,300	300	550	Primary-secondary, dilution tidal flats, San Francisco Bay
Oakland†	51	61	300	410	260	280	Primary, ample dilution, San Francisco Bay

* Average maximum months.
† East Bay Municipal Utility District.

satisfactory dilution of primary effluent.

The Stockton conventional primary settling and biological filter plant is not adequate to handle the combined domestic, industrial, and cannery waste flows during July, August, September and October. The long detention time of cannery wastes in the sewers aggravates the Stockton situation.

The most difficult cannery waste disposal problem in the state is at Modesto. The situation has been successfully and economically solved by a works program conducted jointly by the municipality and the canning industry over a period of eight years.

All cannery waste is collected separately from domestic sewage and other industrial waste. Treatment consists of screening, vacuum flotation, primary settling, and mixing with recirculated secondary pond flow, thence back to the acres of recirculation ponds and again over deck aerators at rates up to 200,000 g.p.m. After recirculation, mixing, and settling, an amount of flow equal to the influent volume of both domestic sewage and industrial waste is diverted to disposal by dilution in the Tuolumne River or onto more than 50 acres of spreading beds and percolation basins.

Disposal to salt water tidal prisms of effluent from a primary plant processing sewage containing large percentages of cannery wastes creates particular odor control problems such as occur at San Jose. The high sugar content of the effluent consumes oxygen quickly and also provides nutrient for growth of sulfur-splitting bacteria with the result that considerable quantities of hydrogen sulfide are produced in the sloughs and the mud flats. At the East Bay Municipal Utility District Works, as at Sacramento, a large volume of diluted cannery waste is satisfactorily treated in a primary plant and the effluent diluted in the large deep-water flows of San Francisco Bay.

Industry Studies

The canning industry has been cognizant of the problems connected with the disposal of cannery wastes and has taken the initiative in studying the technical factors involved. It has investigated, through national and state associations, proper designs for screening facilities. Recommendations have been issued on operation and management of land disposal works, and projects have been set up to try to accomplish by-product recovery.

Conclusion

No substantial increase in California fruit and vegetable canning production is probable. The majority of canneries are located within cities or adjacent to their boundaries. Consequently, nearly all canneries will be discharging their liquid wastes, and in many cases their disintegrated solids, to municipal or district sewerage systems by 1970.

If the combined flow of cannery waste and domestic sewage has a B.O.D. value greater than 450 to 600 p.p.m., all practical steps should be taken to provide for separate collection and treatment of the cannery liquids. The problems encountered in treating strong combined sewage and cannery wastes will be simplified by continued population growth.

Difficulties encountered in (a) the operation of California sewage treatment plants, (b) the management of land areas on which wastes are spread, or (c) in diluting cannery wastes in water courses are not only related to the B.O.D. but also to the settleable solids content. Frequently liquid waste disposal difficulties arise because settleable solids (a) fail to settle in primary tanks, (b) accumulate on land areas, or (c) create sludge banks in water courses.

With continued population growth, difficulties will increase in the disposing of solid wastes as garbage. Special

attention must be given to the magnitude and seasonal character of the "garbage" phase of cannery wastes disposal in developing area-wide long range plans.

Investigators and authorities in the field of cannery by-product recovery do not anticipate that general uses for cannery wastes are likely to be discovered which will result in economical conversion of these materials. Only the conversion of selected portions of "prime" garbage, which is rich in sugars, nitrogen, or other valuable solubles has shown any promise. Even then, the probable increased use of solids wastes will be as fertilizer or for stock feed. The latter is feasible only when costs of drying are carefully managed.

MEETINGS OF INTEREST

1957

Mar. 19–20 **Tenth Municipal and Sanitary Engineering Conference,** University of Florida, Gainesville, Fla.

Mar. 20–22 **Twentieth Annual Short Course,** Superintendents and Operators of Water and Sewage Plants, Louisiana State University and Agricultural and Mechanical College, Baton Rouge 3, La.

Mar. 28–29 **Eleventh Annual Industry-Faculty Conference,** Louisiana State University and Agricultural and Mechanical College, Baton Rouge 3, La. Frank T. Carroll, Jr., Assistant to the Dean, College of Engineering, Baton Rouge 3, La.

Apr. 1–2 **Sixth Southern Municipal and Industrial Waste Conference,** North Carolina State College, Raleigh, N. C. Dr. Nelson L. Nemerow, Operating Committee Chairman, North Carolina State College, Raleigh, N. C.

Apr. 1–12 **Residential Course on Trade Wastes,** University of Durham, King's College, Newcastle upon Tyne, England. Peter C. G. Isaac, Senior Lecturer, Public Health Engineering, Dept. of Civil Engineering, University of Durham, King's College, Newcastle upon Tyne, England.

Apr. 4–5 **Eight Annual Pacific Northwest Industrial Waste Conference,** State College of Washington, Pullman, Wash. William H. Knight, Technical Extension Services, State College of Washington, Pullman, Wash.

Apr. 15–19 **Rocky Mountain Water and Sewage Operations School,** University of Colorado, Boulder, Colo. Associate Professor Walter A. Weers, Dept. of Civil Engineering, University of Colorado, Boulder, Colo.

Apr. 24–26 **Sanitary Engineering Conference,** Manhattan College, New York, N. Y. Assistant Professor W. W. Eckenfelder, Jr., Civil Engineering Dept., Manhattan College, New York 71, N. Y. Conference subject, "Solids Handling and Anaerobic Digestion."

May 12–17 **American Water Works Association,** Atlantic City, N. J. Harry E. Jordan, Secretary, 2 Park Ave., New York 16, N. Y.

May 13–15 **Twelfth Purdue Industrial Waste Conference,** Purdue University, Lafayette, Ind. Professor Don E. Bloodgood, School of Civil Engineering, Purdue University, Lafayette, Ind.

WASTES TREATMENT FACILITIES AT UNITED STATES AIR FORCE INSTALLATIONS*

By John E. Koruzo

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The United States Air Force is an independent and autonomous military institution separate and distinct from the Departments of the Army and Navy. It operates in coordination with the Army and Navy military services for defense purposes. Coordination in military matters is effected by the Joint Chiefs of Staff for Air Force, Army, and Navy. The Chiefs of Staff are under the direct authority of the Secretary of Defense in cooperation with the Secretaries of Air Force, Army, and Navy. The Army and Navy have individual air forces which are specific to their strategic requirements and which should not be confused with the over-all functional requirements of the U. S. Air Force as an independent fighting organization.

The U. S. Air Force chain of authority extends from the Air Force Chief of Staff at Washington through the major and minor air commands to Air Force strategic, tactical, training, research and development bases associated with these specific mission requirements.

The Air Force bases are self-contained municipalities with an average population of 10,000 at major bases. They have their own railroads or siding facilities, paved roadways and streets, and collective and individual housing facilities. Hospitals, laundries, food processing and dispensing facilities, and automobile gas stations are also installed. All utility requirements common to municipalities are available such as water supply, sewage collection and treatment, garbage collection and disposal, and electrical and heating facilities. Therefore, Air Force installations are plagued by the same problems and practices that municipalities have to cope with.

As of December, 1955 there were approximately 170 sewage treatment plants in operation at Air Force installations in the United States. The Air Force also operates a large number of plants at overseas installations. In the United States alone, the total sewage treatment plant investment exclusive of collection systems and appurtenances is more than $151,000,000. This investment has been increased by recent expansion and newly constructed installations.

Total sewage discharges have averaged as much as 77 m.g.d. Of this total 4.3 m.g.d. were not treated; 18.2 m.g.d. were treated at municipal facilities or by contract; 11.3 m.g.d. were given primary treatment and sludge digestion; and 43.2 m.g.d. were provided secondary treatment by oxidadation and secondary sedimentation. These quantities have also been increased by the construction of recent installations.

It should be evident, therefore, that the Air Force is doing its share to alleviate stream pollution problems by providing 90 per cent of its installations with either base or municipal treatment facilities. The provision of these treatment facilities is in conformity with a Presidential order calling for the maintenance and conserva-

* Presented at the 1956 Annual Meeting, Pennsylvania Sewage and Industrial Wastes Assn.; University Park, Pa.; Aug. 29–31, 1956.

tion of water supplies. The latest U. S. Public Health Service reports indicate that only 57 per cent of the municipalities in the United States which require sewage treatment have provided adequate facilities.

Sewage Facilities

Air Force sewer systems consist of tile, cast iron and concrete pipes ranging in size from 6 to 30 in. House connections are 6-in. terra cotta pipe. Sewer design is based on three times the average flow and the water consumption rate is considered to average 150 gal. per capita. This design standard includes capacity for aircraft washing operations, food dispensaries, and other normal base operations exclusive of irrigation, photo-processing laboratories, or other high-capacity water users. These high-capacity requirements are added to the per capita allowance for water design purposes. Sewage facility designs are based on 100 gal. per capita per day. Separate sewer systems are the rule for Air Force installations; there are no combined systems.

In general, Air Force sewage is more concentrated than municipal sewage. It usually has a greater proportion of volatile matter in relation to total solids, and it contains a higher proportion of grease compared with municipal sewage. The flow is subject to rapid and extreme variations. Base personnel arise, eat and go to bed at the same time, creating peak sewage flows that can be predetermined to some extent but can not be relied on because of military missions. The high concentration of sewage is due to the absence of diluting water from large water users and the greater organic content of wastes from predominantly male populations fed on high caloric foods. Laundry wastes are usually acceptable for treatment in sewage plants if the flow range does not exceed 15 per cent of the daily sewage flow and input is regulated to prevent "slugging." If the waste is not acceptable in a sewage treatment plant, the Air Force provides individual or combination treatment with other industrial wastes.

Arctic Installations

Waste treatment is necessarily complicated by geographic location and military mission requirements for the Air Force bases. In Arctic areas special consideration must be given to the collection and transport of sewage wastes. At large bases in these areas, water is usually hauled from the supply source or conveyed to a central distributing point. Pumping stations are inclosed and heated, and the water is conveyed through steam or electrically heated water lines usually laid on the ground because of perma-frost conditions underground. The water is conveyed to water storage tanks located in a heated building provided with two or more stands for filling tank trucks. Heated trucks transport the water to individual buildings on the base, each provided with individual water storage, waste-water, and sewage collection tanks.

The water used in the building is conducted to the waste-water receiving tanks. Hand pumped marine-type toilets draw water from the waste-water receiving tanks for flushing purposes and discharge it to the sewage collection tanks. Heated sewage-collection trucks convey the sewage from these individual buildings to a centrally located heated sewage-collection building for elimination. This building is not air conditioned but it is well ventilated. The collected sewage is then conducted through a heated sewer line for disposal into a body of water or distant uninhabited location, of which there are many in the Arctic. The large bases have submerged outlets which extend into large bodies of water. Fortunately, the Air Force is not faced with the problem of providing sewage treatment facilities in these areas.

The water and sewage facilities described do not provide the most desir-

able sanitary conditions, but economic and extreme weather conditions create a complex problem for the installation of conventional facilities. This is a simple but practical sanitary solution, and the problems are mainly those of good housekeeping at each sewage-collection point.

Normal Installations

For normal installations, general municipal practices are followed for the installation of sewage treatment facilities. The Air Force has all types of sewage treatment plants ranging from septic tanks to activated sludge processes. Plant design capacities range from 10,000 g.p.d. to 4 m.g.d. Flow variations presented by the fluctuating populations and pyramided peaks present the treatment plant operators with continuous operating problems. However, design changes have been made so that single-unit tanks in sedimentation and oxidation units are no longer installed, with the exception of small plants serving up to 500 persons. As a result, the operational problems have been lessened.

Small Installations

Sewage treatment facilities for small installations, which serve from 100 to 300 persons and located at almost inaccessible locations near mountain tops, give the Air Force the most complex problems. When these installations were originally proposed for construction it appeared to be a simple matter to provide septic tanks because of the isolated locations away from habitable areas. However, the wild life leagues of the various states involved soon forced a change in treatment requirements.

In order to provide complete treatment, the most practical solution at first appeared to be the installation of underground sand filters as an over-all standard to prevent freezing, limit maintenance, and reduce the requirement for operating personnel. This was satisfactory until it was found that the construction personnel overloaded the septic tank and filter before the base occupying force took over. This condition was due to the fact that the construction personnel greatly outnumbered the occupying force and filter clogging did not become apparent until the base was in operation for some time.

The underground filter installations cost as much as $45,000 to serve a population of 200. The rehabilitation cost almost equaled the original cost. Consequently, it was decided that a better practice would be to construct conventional treatment facilities above ground where personnel could see the facility and maintenance requirements would become evident. This decision required operating and maintenance personnel, but the deterrent factor was the cost for the installation. The installation of small Imhoff tanks, trickling filters, and final sedimentation tanks became too costly because of the long distances required to haul construction materials to the proposed installation sites.

Air Flotation

The Air Force is planning to try a gas compression and flotation unit, which was adopted for processing aircraft-wash wastes, for the treatment of sewage at the small installations. This is a "packaged" steel unit which can be moved from one place to another if necessary. The unit will be installed at Grandview AFB, Mo., in close proximity to an existing trickling filter plant. The location was chosen in order to utilize competent operation and maintenance personnel for both the sewage treatment plant and for the aircraft-wash waste operations, and so that a firm evaluation could be made of the applicability of this unit to sewage treatment.

For this evaluation the existing comminutor at the sewage treatment plant will be adjusted to provide as small a sewage particle size as possible. Sumps, pumps, and lines will be installed so the flotation unit can receive raw sew-

age or primary effluent at rates of 25 to 75 g.p.m. The air compression chamber of the flotation unit will be designed to provide a compression rate up to 75 p.s.i. instead of the existing 45 p.s.i. used for aircraft-wash wastes treatment. The flotation unit itself will have a detention period of 15 min. based on a flow of 75 g.p.m. This is the standard for aircraft-wash wastes. Recirculation facilities will be provided to pump either effluent or sludge from the sludge receiving tank back to the compression chamber or influent to the flotation tank. Sludge can be pumped to the existing sewage treatment plant sludge beds or digesters. However, the sludge will be evaluated for stability without digestion.

The theory on which this choice of equipment is based is that the air compression of the finely divided sewage solids and the release of the solids to atmospheric pressures in the flotation tank will create myriads of microscopic air bubbles which will maintain oxygen values in the effluent of the flotation unit. The time element involved may not prove to be sufficient. However, the degree of stabilization will be evaluated carefully. It is anticipated that at least 65 to 70 per cent B.O.D. reduction of the raw sewage will be obtained and that there will be a partial stabilization of the sludge by oxygenation. A careful evaluation will also be made on flotation treatment for primary sedimentation tank effluent. The results of this test could effect the requirements for the use of expensive secondary treatment units in sewage treatment plant installations. Since this will be a full-scale flotation plant installation adjacent to a complete sewage treatment plant, and it will be treating normal sewage, the results obtained should be more comprehensive than those obtained under laboratory conditions.

Aircraft-Wash Wastes

The air flotation process has been successfully used for the treatment of aircraft-wash wastes. Washing compounds consist of a mixture of "gunk," a crude soap, mixed with kerosene which is considered to be the carrying agent for applying the washing compound to aircraft surfaces. The mixture is made up of 7 to 9 gal. of kerosene to 1 gal. of gunk, the cleaner. The quantity of washing compound used is in the order of 200 to 300 gal. of kerosene for large aircraft of the B-36 type. The compound is applied to aircraft surfaces through a spray nozzle under hose pressures of 15 p.s.i. at a rate of 2 g.p.m. The cleaning compound is washed off with cold or hot water at water system distribution pressures, resulting in an emulsified oil in water waste. The total wash waste from large aircraft will vary from 8,000 to 12,000 gal.

While the cleaning compound is being applied to the aircraft there are practically no waste flows for as long a period as 1 hr. When the wash water is applied, waste flows may reach a peak rate of 75 g.p.m. for another period of an hour. The maximum hourly flow will approximate 4,500 gal. These operations are repeated until the aircraft is completely washed, which may take from 6 to 8 hr.

The characteristics of the waste are as follows:

Oil and grease (p.p.m.)	800 to 5,000
pH	7 to 9
Turbidity (p.p.m.)	1,600 to 8,500
Suspended solids (p.p.m.)	Nominal*
Total solids (p.p.m.)	Nominal*
Temperature (°F.)	Ambient

* Exclusive of grease and oil.

Flotation Unit

The intermittent flow of wash waste creates treatment problems. The first flotation units installed had a 3,000 gal. surge tank as an integral part of the unit. It soon became apparent that this tank served no purpose because it did not regulate flow, provide pH equalization, or adjust temperature requirements for subsequent chemical cracking of the emulsified wastes. To

complicate the problem Air Force operations decided the kerosene should be recovered because it was applicable for re-use. Larger ratios of kerosene to cleaner in the washing compound mixture produced as good a cleaning agent as a larger proportion of cleaner to kerosene. The cleaner cost was about $0.60 per gallon, whereas the cost of kerosene was $0.08 to $0.10 per gallon when purchased in quantity. This kerosene recovery requirement added immensely to the treatment problem.

Features

Since the wastes are treated on a continuous flow basis, a 12,000-gal. surge and equalization tank was installed to increase the detention period. This provided sufficient time for pH and temperature equalization and for kerosene flotation, which required a minimum detention of 1 hr. The surge tank was equipped with grit hoppers at the influent end for manual removal of grit. Experience indicates that grit removal is a minor problem but the provision for its removal is a good precautionary measure. The tank was also equipped with waste agitating or recirculation facilities for subsequent chemical treatment.

Operation

To remove kerosene, the wastes are detained for at least 1 hr. to allow the kerosene to float to the surface. The kerosene is then withdrawn by means of a slotted pipe or overflow weir to a 500-gal. receiving tank. It is then pumped to a 1,000-gal. washing-compound mixing tank located in the washing control center at the washrack.

After the kerosene is removed, the emulsified waste and contents in the equalization tank are agitated and the pH and temperature are adjusted. The equalization tank effluent flows to a receiving sump to be pumped at a constant rate to a circular, totally enclosed steel gas compression chamber where pressures are maintained at 25 to 45 p.s.i. The pump to this chamber is equipped with a rotometer to regulate the air input in the chamber and an aspirator to draw atmospheric oxygen into the flow to provide the necessary air in the compression chamber. Iron salts, calcium chloride, or other chemicals also are introduced into the compression chamber with the pump suction. An automatic air release valve regulates the pressure in the compression chamber. The chamber provides about a 5-min. detention period. When the waste mixture containing the dissolved air is released to atmospheric pressure in the flotation unit, myriads of microscopic air bubbles inclosed in the solids carry the solids to the surface of the unit. The detention time in this unit is 15 min.

Sludge Disposal

The floated sludge or scum is collected by flight collectors which convey the sludge to a receiving tank constructed as an integral part of the flotation unit. The sludge can be either conveyed by gravity or pumped to sludge drying beds, or loaded into tank trucks or containers for final disposal by hauling to a sanitary fill or other disposal area. Sludge drying beds usually are not used unless they are so located that the sludge can be burned without creating a nuisance.

Results

The large equalization tank has eliminated and simplified the previous problems, and pH, flow, and temperature are controlled automatically. The amount of gas compression required in the compression tank has to be determined by trial and error for each location. The detention period in the flotation unit appears to be adequate for the treatment of aircraft-wash wastes or a combination of aircraft motor pool and engine test-cell wastes. The effluent is disposed of to a stream or to a sewage treatment plant for further treatment if conditions warrant. Flo-

tation equipment must meet the following effluent requirements:

Item	Maximum Allowable Concentration (p.p.m.)
Oil and grease	30
Suspended solids*	30

* Exclusive of oil turbidity and floc.

In most cases the units produce effluents with no more than 10 to 15 p.p.m. of oil and grease.

Costs

The average cost for a complete washrack installation for large aircraft will be approximately as follows:

Washrack	
Washrack paving† and utilities piping	$52,000
Control building and equipment	15,000
Kerosene storage tank and pumping facilities	3,000
Access taxiway	5,000
Subtotal	$75,000
Waste Treatment	
Flotation unit	$12,000
Equalization tank with appurtenances	5,000
Sludge disposal equipment	5,000
Piping	5,000
Subtotal	$27,000
Total	$102,000

† Paving, 4,540 sq. yd.

Conclusion

One of the major problems at Air Force sewage treatment installations is maintenance of the facilities, in view of the various geographical and climatic conditions encountered at the world-wide locations of the bases.

The Air Force recognizes that effective maintenance is as important as the design and construction of the facilities. Accordingly, incorporated into the plans are design features which will result in reduced maintenance problems, even though the initial construction cost may be slightly higher. Considering the long term operation of these facilities, this practice is well worth while.

The Air Force has furnished sewage and industrial waste treatment facilities at 90 per cent of its installations. Treatment units range from septic tanks to activated sludge processes, and they must be installed and operated under a wide range of conditions. Every effort is made to conform with the national policy of stream pollution abatement.

WORLD HEALTH DAY—APRIL 7

The United States is joining with other nations in the observance of World Health Day, April 7. The theme this year is "Food and Health" in observance of programs dealing with nutrition, food production and distribution, and food protection and sanitation. World Health Day commemorates the anniversary of the adoption of the Constitution of the World Health Organization. A different theme is chosen each year to encourage countries to improve various aspects of their health programs.

INDUSTRIAL WASTE TREATMENT AT MODESTO, CALIFORNIA *

By Marvin Ray

Director of Public Works, Modesto, Calif.

Modesto is a small city in the San Joaquin Valley of California with a population of about 33,000 people. During the last six years the population of this community has approximately doubled. This population increase has resulted in all of the various problems associated with rapid community growth; however, the industrial wastes disposal problem was present before this rapid population expansion occurred.

Located in the heart of a highly developed agricultural area, it was only natural that Modesto would be the site of a number of food processing plants. The high volume of seasonal industrial wastes, complicated by the fact that receiving waters were limited in capacity, made it necessary for this small city to take bold steps in order to assure an answer to its critical situation.

It is hoped that this report of the works program of Modesto will be helpful to those municipal officials who are having difficulties in selling a program for adequate disposal of industrial and domestic wastes to the residents of their communities. The residents of Modesto are proud of their accomplishments which have typified a desire on their part to think big and build big, in order to provide for security in the future. This is typical of the community endeavors which have won for Modesto recognition as an "All American City."

* Presented at the 29th Annual Meeting, Federation of Sewage and Industrial Wastes Assns.; Los Angeles, Calif.; Oct. 8–11, 1956.

Historical Background

Treatment of domestic sewage and industrial wastes dates from 1910, when the City of Modesto purchased 38 acres for the purpose of constructing sewage disposal works. Prior to that time, all the wastes from the city were discharged into the Tuolumne River without treatment. This is a small stream with an average flow of 200 to 300 c.f.s. during the summer. The city subsequently purchased additional land adjoining the original site and now owns 160 acres.

During 1911, a trunk sewer line was constructed from the city to the disposal site which was then called the "Sewer Farm." A Cameron tank was constructed, and the sewage flow was then diverted from the river through this tank. The lines to the sewer farm also carried substantial quantities of industrial wastes. During the following 25 years additional facilities were added for the treatment of domestic sewage but none for industrial waste treatment.

From 1938 to 1944, extensive studies were made to determine the existing and expected future volumes of both domestic sewage and industrial wastes. It was apparent from these studies that additional treatment for both types of wastes was necessary. Unfortunately a bond issue was defeated by ballot in 1945.

In 1946, a suit was filed by the California State Division of Fish and Game against the City of Modesto and major industries of the community, charging them with pollution of the waters of the Tuolumne

River. This action resulted in activation of a citizens committee to carry full information on the problem to the public. As a result a bond issue for $1,200,000 was carried by a large majority of the voters in an election held in December, 1946.

These funds, together with other revenue raised from general taxation, were utilized to provide a number of facilities at the treatment plant principally devoted to the expansion of industrial treatment facilities. The major units included in the construction program were (a) a large trunk line from the city to the plant site, (b) 21 acres of oxidation ponds, (c) a 54-acre percolation bed, (d) a deck aerator for stream aeration of industrial wastes, (e) sludge drying beds, and (f) pumping and screening facilities. This work was completed in 1949, and a vacuum flotation unit for industrial wastes solids removal was completed and placed in operation in 1950. This unit is 50 ft. in diameter, and one of the largest units of this type built to date.

While all this construction greatly improved sewage treatment, the problem was far from solved, and the previously mentioned law suit was still pending in the courts. Industrial and residential growth of the Modesto area had resulted in a sewage volume far beyond the capacity of the treatment plant. Consequently, raw or partially treated sewage was still being discharged into the river. The situation was so critical that the city was faced with the loss of several of its major industries, and it was recognized by many citizens that only a start had been made toward ultimate solution of the problem. Here was a small city of less than 18,000 population with a loading on its plant during the winter months equal only to the domestic sewage flow. During the summer, the seasonal loadings rose to the equivalent of a population of 450,000. Records show that B.O.D. loadings of up to 90,000 lb. per day were received at the plant. These wastes had to be treated and the effluent discharged into a stream that was capable of receiving, on an average summer day, a total B.O.D. of only 6,200 lb. Only 75 per cent (4,650 lb.) of this capacity is available to the city.

Approach to the Problem

When the city changed its form of government to that of a council-manager type in 1951, the new council and city manager found that the number one problem was sewage disposal. Beginning in 1952, an intensive study was made on the needs for waste treatment facilities in order to supply data for long range planning. This study culminated in a program for expansion which was placed before the citizens in a bond election in April, 1953. The bond issue was in the amount of $2,450,000 and was approved by the voters by an 8 to 1 majority. Based on the success of the bond issue, and after a firm commitment had been given by the city that it would proceed immediately to solve its waste problem, the suit filed by the Fish and Game Commission was dismissed.

The bond election was overwhelmingly successful because many of the citizens of the community participated in a well-organized program for providing full, factual information to the voters of the city. It must be remembered that these voters were obligating themselves by a general obligation bond issue of nearly $2,500,000 to care for the needs of a city of about 100,000 population.

Since that time almost unbelievable progress has been made in the expansion of the city's sewerage system, and in planning, designing, and constructing additional treatment facilities. Since April, 1953, 14 miles of trunk sewers for carrying domestic sewage and industrial wastes have been designed and constructed. During this same period 20 miles of sanitary sewer

laterals were built. The trunk sewers were financed by the bond program.

It was also during this period that most of the expansion in the city's population occurred. This was due to the fact that the heavily populated fringe areas came to the conclusion that if the people of this city were farsighted enough to provide essential sewage disposal facilities for the future, they wanted to be a part of it.

The design and construction of trunk sewer facilities for a rapidly expanding community present a serious problem, but the difficulties associated with the design of treatment works for an expanding community are even more serious. Much time, careful thought, and study went into the consideration of this phase of the expansion. It is a tremendous responsibility to expend public funds for purposes such as this, and the city officials wanted to be sure that any steps taken were the right ones.

Sewage lagooning was not considered an acceptable method of treatment because the area around the treatment plant was built up with a fairly heavy concentration of residential developments. It was generally agreed by the consulting engineer and the city engineering staff that other types of treatment would be required.

While careful planning was needed in order to ultimately determine the type of plant to be constructed, there were some units on which work could begin immediately. An extension of the deck aerator was completed in October, 1953 and a 90-ft. diameter digester was constructed for digestion of industrial wastes.

The next step was to undertake jointly with the consulting engineer and an equipment company an intensive study of waste treatment at the neighboring city of Hayward, in the San Francisco Bay Area. This city was selected because it had a large volume of industrial wastes from canneries and used some of the same treatment units that were in existence at the Modesto treatment works, particularly the vacuator and deck aerator. The City of Hayward provided the facilities for the testing program, with expenses being shared equally by the other participants. Unfortunately, the testing program indicated that the wastes at Hayward were sufficiently different to be of little value in solving the Modesto problems.

The conclusion was reached, however, that certain plant units could be constructed for Modesto and placed in service with initial benefits to be gained, pending determination of the final plant units to be constructed. Following this decision, plans were prepared for the construction of a clarifier and biofilter. Each unit was to be 200 ft. in diameter. The filter distributor has six arms and a capacity of 30,000 g.p.m. The clarifier has a side-water depth of 10 ft. and a volume of 3,500,000 gal. The plans also provided for the relocation and enlargement of an existing biofilter used for domestic treatment, and the construction of a pilot plant. The work was completed in January, 1956 at a cost in excess of $450,000.

Pilot Plant

Treatment plant units constructed under the most recent contract represent about one-half of the ultimate units to be constructed for complete sewage and industrial waste treatment under the present program. The pilot plant is being used on a thorough testing program of the waste treatment problem before designs will be made and construction begun on the remaining treatment units. Units of the pilot plant, which is one of the most complete plants ever constructed by a city of any comparable size, are as follows:

1. A clarifier with a diameter of 10 ft. and a side-water depth of 4 ft.
2. A biofilter with a diameter of 17 ft. and a rock depth of 3 ft.
3. Two mixing tanks, each with a diameter of 10 ft. and a water depth of 5 ft. The mixing tanks

are also equipped with diffusers for the addition of air.

4. A deck aerator 10 ft. by 15 ft. in size.

Included with the units are the necessary pumps, blower, diffuser tubes, flow and air metering equipment, and piping and appurtenances to provide a complete operating unit. The pilot plant has an operating range of 20 to 200 g.p.m.

Of special interest is the fact that this unit was a joint project with the consulting sanitary engineer and the suppliers of some of the equipment. With certain equipment items and services being provided gratis or at cost, the net cost to the City of Modesto was $12,000.

As previously stated, it is planned to conduct a thorough and extensive testing program of the wastes by utilizing the activated sludge and biofiltration processes. It is expected that the results obtained from pilot-plant operation during 1956 and 1957 will provide factual data from which can be determined the type of treatment that will provide the best results.

Upon completion of the test program the pilot plant will be utilized for plant control in order to carry out various experimental projects. The plant will also be made available for studies in the sewage and industrial waste treatment field.

Present Operation

The present industrial waste treatment plant consists of an industrial waste pumping station, bar screens, rotary screens, a vacuator, a 200-ft. diameter clarifier, a 200-ft. diameter biofilter, 20 acres of oxidation ponds, and a deck aerator. The units treating the domestic sewage are a detritor, comminuters, a 60-ft. diameter clarifier, and a 100-ft. diameter biofilter. The effluent from the filter flows to the 200-ft. diameter clarifier where it is mixed with the industrial wastes. There are also three digesters. One is 90 ft. in diameter and is used for digestion of industrial sludge. The other two units, each 60 ft. in diameter, are used primarily for digestion of domestic sludge.

The operation of these units during 1956 indicates that sufficient treatment is being obtained at present plant loadings to allow ample time for the conduct of tests with the pilot plant prior to construction of additional units. It is presently planned that when the plant is finally completed it will have a capacity of 30 m.g.d., of which approximately two-thirds would be industrial wastes and one-third domestic sewage. Present average loadings during the summer months are about one-half these amounts.

Operational Problems

Many difficult problems have been encountered by the operators of the treatment facilities during the past several years. These difficulties were, of course, engendered by the fact that the volume and strength of the industrial wastes and domestic sewage were far beyond the capacity of the treatment facilities or the receiving river. In order to accomplish as much as possible with available funds, various attempts were made to provide treatment facilities at a low initial cost. For example, oxidation ponds were constructed. These consisted of a primary pond and a secondary pond, each with an area of slightly more than 10 acres, and with a water depth of 5 ft. These recirculating ponds were piped to the deck aerator, which was equipped with four low-head pumps, each having a capacity of 50,000 g.p.m. These ponds and the deck aerator were instrumental in relieving a considerable portion of the industrial waste load. Records indicate that up to 200 lb. of B.O.D. per day per acre-foot can be handled satisfactorily by these two units. This exceeds any comparable loading for ponds without recirculation and aeration.

Other measures included the use of numerous chemical compounds for odor control. Up until 1952, chlorine was used for odor control in the ponds and at the deck aerator. Odors were an extremely severe problem with many complaints received daily from residents of the surrounding area. As much as 4,000 lb. of chlorine per day were used for this purpose, but without eliminating complaints.

In 1952, an enzyme catalytic soil conditioning agent was successfully tried for odor control. This material was added to the industrial wastes at the rate of 10 p.p.m. during the summer months of 1952, 1953, 1954, and 1955. The enzyme was not used in an attempt to stimulate sludge digestion, but was used solely for purposes of odor control and in order to obtain increased percolation in the oxidation ponds. Regardless of what may be said otherwise about this type of material, the results obtained were satisfactory, both as to odor control and increased rates of percolation in the oxidation ponds and percolation beds. The percolation rate while using these materials was 70,000 gal. per acre per day. Unfortunately there are no records to compare this rate with the same ponds prior to use of these materials. Incidentally, the use of the enzyme catalyst was only of an emergency nature. Materials of this type have not been used in 1956.

Laboratory Control

The type of treatment plant facilities, and the requirements of the California State Water Pollution Control Board have made it necessary to maintain a laboratory set-up which is probably more complete than in most cities of the size of Modesto. Only the standard tests are made on the plant operation. However, during periods of low flow in the Tuolumne River, daily dissolved oxygen tests are made on a 10-mile section of the river. A minimum D.O. content of 3 p.p.m. is required to be maintained throughout the year. During the salmon run, which occurs in the latter part of September and October, the minimum D.O. content requirement is increased to 5 p.p.m. This is a period when the load on the plant is nearly at its peak. Since it is essential that the river be utilized to its full capacity, checks are made both above and below the plant outfall to assure that the minimum D.O. content is maintained.

Another reason that additional laboratory work is required is that the industrial waste fees are based on volume and strength. Volume is determined by metering either the wastes discharged or the water used by each industrial plant. The strength of the wastes are determined by the B.O.D. test. A minimum of four samples per month is required from each industry and these are analyzed in the treatment plant laboratory. This method of determining industrial waste charges was placed in effect in March, 1955 and has now been accepted by the various industries in Modesto. Incidentally, since institution of the volume basis, some plants have installed water-saving devices, and water usage has been reduced about 1.5 m.g.d.

Another load on the treatment plant laboratory facilities is created by the intensive testing program at the pilot plant. Special personnel have been obtained for this purpose.

Conclusion

The magnitude of the problem encountered by Modesto in the treatment of industrial wastes is not unusual for many communities that have experienced rapid population and economic growth. However, to preserve its own immediate economic life and to protect the future of the community, it was essential to undertake a comprehensive program of sewage and industrial waste treatment.

Stream Pollution

POLLUTIONAL EFFECTS OF HYDRAULIC POWER GENERATION

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The degrading effect upon downstream water quality of impoundments used for hydraulic power generation is a fact not generally realized by sanitary engineers. The use of quiescence in water or waste treatment improves the quality of the surface or upper layer of the pond, lagoon, or settling tank, because quiescence reduces the suspended solids quickly. In addition, the prolonged storage of water generally reduces the bacterial count (1) and biochemical oxygen demand (B.O.D.). Thus, water downstream from an impoundment generally looks better, especially during rainy weather, than water in streams without any impoundment upstream.

The water discharged downstream from power generating facilities does not come from the top of the reservoir, but from a point about one-quarter of the distance from the bottom of the impoundment to the flood gate elevation. This is high enough to gain some of the advantages of storage, yet low enough to show the effects of biochemical activity upon the deep water of a temperate-zone lake.

In late 1954, Davidson and Churchill (2) published a discussion of the interrelation of water quality from stream regulation, impoundment, and stream pollution. Some of the factors discussed by these authors will be reviewed in this paper and some factors will be presented that may have been considered but not emphasized by them.

The deterioration of water quality in the stream below the impoundment does not imply that poor quality or polluted water is entering the lake such as that described by Lawrence (3) on the Androscoggin River. Most of the deterioration of water quality in the river downstream, which is a result of a loss of dissolved oxygen caused by biochemical activity in the hypolimnion, is normal to lakes or impoundments in the temperate zone (4).

The problem of poor water quality, already technically involved, is further complicated by certain legal considerations. Power companies, either federal or private, operate large dams for hydraulic power under federal licenses. Furthermore, the attitude is taken by some power companies that they are not polluting the water, for pollution is frequently defined as the addition of something deleterious to the water. The hydroelectric dam deteriorates the water by reducing the D.O. content as a result of natural causes. The main point is that pollution should be defined as "that act of man's use which causes deterioration in water quality such that the downstream user shall be materially damaged." This definition does not require that something be added to the water.

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Thermocline Considerations

The development of a thermocline in a lake may be the result of normal processes in a natural lake, and it may be aided by the operation of the impoundment (lake) for flood control. For the latter purpose the water level is reduced in the late fall to a predetermined minimum by the first of January, according to Davidson and Churchill (2). As the probability of flood-producing rains decreases with the advance of spring, the pools are gradually filled.

With the rise in water level with the changing seasons, there is also a rise in the water temperature of the incoming water which tends to layer on the surface of the pool. The draft tube of the generator continues to receive water from the cold water at the bottom of the pool. Even without the inflow of warmer water over the cold water of the winter pool, the warm spring sun will warm the surface water to a value that will induce a thermocline and thus divide the impoundment into two pools. Much of the organic debris entering the upper pool settles into the lower pool where it induces a B.O.D.

Because much of the effect of impoundment for power generation appears to harm downstream users of water, it should be pointed out that there are some beneficial effects. There is generally a larger average daily flow at low water with the dam than without the dam. Furthermore, where the downstream water is used for cooling steam power plant condensers, the lower temperature of the water from the hypolimnion increases the efficiency of the fuel markedly (2). This factor has been considered in the location of steam power stations by the Tennessee Valley Authority (2).

Effect of Operating Schedules

In addition to the quality of water below an impoundment, the operating schedule of power turbines has an influence on the use of the river for the disposal of wastes into the river immediately below the dam. The hydraulic power dams are operated to give either a minimum or an average flow of water downstream. Because the effect of pollution is generally inversely related to the quantity of water in a stream, it is obvious that for sewage or waste disposal the minimum flow downstream is the most important value. However, the extent of increase in the rate and duration of water discharged for high-power demands is dependent upon the water available and the power demand.

Normally the minimum amount of water is discharged at night when only one turbine operates. As the day's power demand increases, turbines are put into operation in increasing numbers. This may involve a 4- or 5-fold increase in water volume in less than an hour's time as the power generation increases. An increase of 30 in. in the water level in the main stream can result, according to observations on the 525-ft. wide Catawba River. As many industrial uses of electrical power stop at 5:00 P M, the turbines are again shut down. This sort of an operating schedule is called "peaking."

Because the successful use of a stream for wastes discharge is dependent on the level of dissolved oxygen that can be maintained, the discharge of water with a low D.O. content limits the amount of pollution that can be accepted without further obvious damage. When the discharge occurs in a state with stream classifications which prescribe the minimum river levels of dissolved oxygen at the oxygen-sag point, the initial D.O. value may necessitate the spending of many thousands of dollars by the polluter to prevent fish kills for which two parties are responsible. In general, the states can not control the low D.O. values caused by the power dams, but

they can force the municipalities and industries in their jurisdiction to reduce their pollution load.

Catawba River Study

In order to know the pattern of D.O. values below the hydroelectric dam on the Catawba River, S.C., the D.O. content was determined at the Rock Hill, S. C., water intake. This point is seven miles below the Duke Power Company dam. The analyses were continued over a period of 55 days by taking D.O. samples every 2 hr., with a duplicate bottle for a B.O.D. determination set aside twice each day. The results given in Table I show the averages of the 12 daily D.O. observations, the average B.O.D. values and the minimum daily D.O. value. On 22 of the 55 days, the average D.O. values did not meet the South Carolina State Sanitary Code for drinking water in the upland part of the state; the minimum D.O. values met the state code requirement on only 5 of the 55 days.

Assumptions

The order of magnitude in the deterioration of the water from the dam may be gained from the following assumptions and calculations. In flowing water a D.O. drop is brought about by an oxygen demand. If the D.O. drop below a dam was transposed mathematically to a B.O.D., then the load from the dam could be calculated as a population equivalent.

The dam on the Catawba River discharges water at 27° C. with a saturation D.O. value of 8 p.p.m. The water

TABLE I.—Condition of Catawba River at Rock Hill, S. C., Filter Plant

Date (1956)	pH	Temp. (° C.)	Dissolved Oxygen (p.p.m.)			Date (1956)	pH	Temp. (° C.)	Dissolved Oxygen (p.p.m.)		
			Avg.	Min.	B.O.D.				Avg.	Min.	B.O.D.
July						July					
1	6.6	25	4.5	3.7	0.3	29	6.7	28	3.5	3.1	0.2
2	6.6	25	4.4	4.2	0.2	30	6.7	28	3.0	2.5	—
3	6.6	25	4.3	4.0	—	31	6.7	28	3.2	2.6	0.3
4	6.6	25	3.6	2.9	0	August					
5	—	—	4.2	3.5	0	1	6.6	27	3.3	—	0.3
6	6.7	26	4.2	3.8	0	2	6.7	28	3.4	3.1	0.4
7	6.7	26	4.2	3.9	0.4	3	6.7	27	3.4	3.0	0.3
8	6.7	26	4.1	3.6	0.3	4	6.7	28	3.6	2.9	0
9	6.7	26	4.1	3.5	—	5	6.7	28	3.2	1.1	0.2
10	6.7	26	4.2	3.7	0.3	6	6.7	28	3.3	3.0	0.1
11	6.7	26	4.2	3.8	0.3	7	6.7	28	3.7	3.0	—
12	6.7	26	4.3	3.8	0.1	8	6.7	29	4.1	3.7	0.7
13	6.7	26	4.2	3.9	0	9	6.7	29	4.1	3.5	0
14	6.7	26	4.1	3.5	—	10	6.7	29	3.9	3.2	—
15	6.7	26	4.3	3.8	—	11	6.7	29	3.9	3.6	—
16	6.7	26	3.5	3.2	—	12	6.7	29	3.5	3.3	—
17	6.7	27	3.8	3.0	0.3	13	6.7	29	3.2	2.7	0.2
18	6.7	27	3.8	3.4	0.1	14	6.7	29	3.3	2.2	0.2
19	6.7	27	3.4	2.8	0	15	6.7	29	3.3	2.5	—
20	6.7	27	4.2	3.6	0.2	16	6.7	29	3.7	3.1	0.2
21	6.7	27	4.2	3.9	—	17	6.7	29	3.7	1.4	0.2
22	6.7	27	3.5	3.0	—	18	6.7	29	3.9	3.5	0
23	6.7	28	3.4	3.0	0.3	19	6.7	29	3.4	2.3	—
24	6.7	28	3.7	3.3	—	20	6.7	29	3.4	1.9	0
25	6.7	27	3.1	2.5	0.1	21	6.7	28	4.2	3.8	—
26	6.7	28	2.9	2.1	0.1	22	6.7	27	4.5	4.1	—
27	6.7	28	2.9	2.7	0.2	23	6.9	28	5.3	4.8	—[1]
28	6.6	28	3.8	3.1	0.1	24	6.9	28	5.6	4.9	—

[1] Manganese disappeared from water.

from the tail race has a D.O. value of 1 p.p.m., or a drop of 7 p.p.m. At 900 c.f.s. there will be 600 m.g.d. or five thousand million pounds of dissolved oxygen per day. This makes a total B.O.D. load at this flow of 35,000 lb. of equivalent B.O.D. per day. This would have a population equivalent for a town of 200,000 people. At the highest flow of 4,500 c.f.s. the population equivalent would be equal to a town of one million people and would have an equivalent B.O.D. of 175,000 lb. per day. It can be seen from these assumptions that the higher the flow, the greater the B.O.D. load becomes, and that a load of 175,000 lb. is very high.

Water Quality

Manganese was found in the river water during 45 to 50 of the 55 days of D.O. observation. It was pointed out by Chambers and Ingols (5) that manganese was found in the water from the Catawba River last summer. Thus, a water plant below an impoundment must be prepared to treat the water for manganese removal.

A water plant or town appreciates the assured quality of water, but not the poor quality. Furthermore, the town or industry adding wastes to the oxygen-deficient water also finds it difficult to meet the state codes for river water quality where the requirements include maintenance of a specific D.O. value (such as the codes of New York, North Carolina, and South Carolina).

Effect of the Controlled Pattern

During the summers of 1955 and 1956 the author studied the effect of the discharge of untreated waste into the Catawba River from the City of Rock Hill, S. C. The wastes from Rock Hill are approximately one-fifth domestic and four-fifths industrial (from a bleachery). These wastes are discharged to Manchester Creek two miles from the town and one mile from the Catawba River; the last half mile is in the river flood plain. According to the available data (4), the oxygen-sag point occurs three miles downstream from the confluence of Manchester Creek with the Catawba River.

During low flow, both sedimentation of suspended solids and slime growths (sewage fungus) occurred on the stones at the bottom of the polluted portion of the Catawba River below the confluence of Manchester Creek. When the rate of flow increased, the depth of water increased, giving a lower and lower air-to-water surface ratio; so that reaeration was increasingly retarded as the flow increased. According to Davidson and Churchill (2), the reaeration coefficient varies inversely with the discharge. Thus, at a point just above the waste discharge from Rock Hill, the D.O. content at low flow was observed as 3.9 p.p.m., although an hour later the D.O. value dropped to 2.7 p.p.m. after a 20 in. rise in water level.

While studying the D.O. pattern at the sag point, several interesting features were observed. The D.O. values at low flow were found to be quite uniform across the river at approximately 3.0 p.p.m. This indicated a rather uniform distribution of the waste across the river at low flow. The water had a clear appearance during dry weather and low flow. There was a heavy growth of *Sphagnum* moss on the stones up to the level of continuous submergence, but little evidence of *Sphaerotilus*.

At high flow, the D.O. content on the polluted side was observed at 0.2 to 2.0 p.p.m., while on the opposite side of the river the D.O. content at that time was 3.8 to 5.5 p.p.m. This indicated much less distribution during high flow than low flow within the same river distance. The most striking difference between low and high flow occurred in the appearance of the water. During high flow near the polluted shore, the water was filled

with floating clumps of *Sphaerotilus*. There also was a high turbidity, indicating a large number of dispersed microorganisms. It was concluded that the sharp drop in the D.O. content on the Catawba River during high flow was the result of several factors:

1. A greatly increased rate of biochemical activity caused by the tremendous increase in microorganisms (possibly a million-fold increase).
2. A small distribution of the water across the river at high flow.
3. A lower reaeration rate.

Observation of the confluence of Manchester Creek and the Catawba River indicated that there was a smaller flow of waste from the creek into the river during the rise in level of the river. Davidson and Churchill (2)(6) indicate that the drop in D.O. content during high flow is caused by the increase in the ratio of waste to river water resulting from a "slug of waste." Observations made on the Catawba River indicated a steady drop in river D.O. content from 2.7 p.p.m. to 0.7 p.p.m. at the oxygen-sag point. It was concluded that scour at high flow is the major cause of the rapid D.O. drop on the Catawba River.

Storage Effect

Along with a decrease in waste discharge from Manchester Creek to the river there is the possibility of wastes storage in the creek. When the river level drops again, the creek will discharge the normal flow plus the stored volume. This will affect the river water quality during falling water. It was roughly calculated that the flood plain stored a million gallons of waste with a 30-in. rise in river level.

Only a few observations of the sag point were made during a falling river stage at the sag point because the drop occurred from 10:00 PM until the early hours of the morning. Observations of the river reported by Linton (7) indicate that the river is in bad shape during the night hours. Any estuaries on the polluted side of the river filled with polluted water during a rising river will discharge this low D.O water during the falling river stage. On numerous occasions this loss in dissolved oxygen was observed in the estuary at the sag point.

Flow Pattern Phasing

On one point that has serious implications, Rock Hill is comparatively fortunate; the high water will pass the sewer outfall at the Manchester Creek confluence during the daytime when the sewer discharges its maximum load. If a large city should be located 12 or 36 hr. downstream from the dam, it would have to contend with the problem of its maximum city sewage load entering the river at the minimum or night discharge from the dam. Thus, it can be extremely important to a city whether its strong day sewage will be in phase or out of phase with the flow pattern from the dam.

Summary

The storage of water for hydraulic power generation has some good features and some very bad features. It is believed that the importance and severity of the bad features are not adequately realized by the sanitary engineering profession.

On the good side, the water below the dam generally has less sediment, color, bacteria, and a lower temperature.

On the bad side, the water below the dam is most adversely affected during the summer when water quality is most critical. Directly below the dam, the water may be devoid of dissolved oxygen and contain manganese and/or sulfide. The pattern of operation may permit slime development on the bottom during low flow and scouring off of the slime during high flow; wastes may be stored in tributaries during a high river stage

and discharged to the river during a falling river stage; and a city may discharge the heaviest sewage load to the river during the minimum river stage if the town is 12- or 36-hr. flow time downstream from the dam.

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AWWA ELECTS NEW OFFICERS

At its annual meeting in January, the Board of Directors of the American Water Works Association elected new officers for 1957. Awardees were also determined and honorary members elected.

Elected to the office of President was Fred Merryfield, Professor of Sanitary Engineering at Oregon State College and consulting engineer with the firm of Cornell, Howland, Hayes and Merryfield. Federation members know the new AWWA President as the past president of the Pacific Northwest Sewage and Industrial Wastes Association and currently an active member of that group.

Lewis S. Finch, Vice-President and engineer of the Indianapolis Water Company, was elected AWWA Vice-President. Mr. Finch is a past president of the Central States Sewage and Industrial Wastes Association and a former Federation Director from that Association.

To the office of Treasurer, the AWWA elected William J. Orchard, retired general manager of Wallace and Tiernan, Inc. Mr. Orchard needs no introduction to Federation members whom he has served long and faithfully in a number of capacities. He has been an Honorary Member of the Federation since 1946. Mr. Orchard succeeded William W. Brush, who had served as AWWA Treasurer since 1922, except for a two-year period during which he was Vice-President and President of the Association. Mr. Brush was elected Treasurer Emeritus.

Four honorary members were elected at the meeting. Among them were Albert E. Berry, Director of Sanitary Engineering for the Ontario Department of Health, Toronto, Canada; and Charles H. Capen, retired chief engineer, North Jersey District Water Supply Commission. Mr. Berry is an Honorary Member and a Past President of the Federation, having served in this capacity in 1944–45.

ORGANIZATION OF COOPERATIVE STATE–INDUSTRY STREAM STUDIES IN WISCONSIN *

By R. H. Scott and T. F. Wisniewski; and
B. F. Lueck and A. J. Wiley

Respectively, Wisconsin Committee on Water Pollution, Madison, Wis.; and Sulphite Pulp Manufacturers' Research League, Appleton, Wis.

This paper reports on the organization of the cooperative state-industry stream studies in Wisconsin as undertaken by the Wisconsin Committee on Water Pollution and the Sulphite Pulp Manufacturers' Research League. The results of the study by this group on the Lower Fox River were reported in This Journal, **29**, 1, 76 (Jan., 1957).

With the ever-growing activities connected with water pollution control, it becomes increasingly and equally important for governmental units participating in such programs, and major industrial plants discharging wastes to surface waters, to obtain as much information as possible regarding conditions prevailing in the receiving waters. The volume of data necessary for a reasonable appraisal of any condition of water pollution requires seemingly unending collection and evaluation. Changes in season, water temperature, industrial waste and municipal waste loading, aquatic plant growth, and stream flow or dilution available are some of the factors which continue to alter the picture presented. The over-all chemistry and biology of waste utilization by surface waters never reaches a point of static equilibrium, but is an ever-changing balance that requires continuous investigation to gain even a partial insight into the complex mechanisms involved and the energy relationships affected by the changing environmental conditions.

If it is then conceded that detailed and sustained compilation of water pollution data is necessary, the problem presented from the collection standpoint develops into one of available manpower and means whereby such information can be obtained. Few governmental agencies responsible for water pollution control have adequate budgets for manpower and expenses. On the other hand, industry is becoming increasingly interested in gaining firsthand knowledge of their individual problems and in participating in pollution control programs within the sphere of their immediate obligations. The pooling of government-industry resources, where possible, enables both to profit.

It is not the purpose of this paper to present a specific program that will be universally applicable to the needs of all who may be concerned with collection of water pollution control data through cooperative effort. However, phases of the government and pulp and paper industry cooperative program as presently developed in Wisconsin will be discussed in the hope that such information may be helpful to other industry and governmental units in the formation of cooperative programs covering water pollution problems of mutual interest.

* Presented at the 11th Purdue Industrial Wastes Conf., Purdue University; Lafayette, Ind.; May 15–17, 1956; under the title "Cooperative State-Industry Stream Studies in Wisconsin. I. Organization of the Program."

Program Development

The development of cooperative stream survey work between the pulp and paper industry and the Committee on Water Pollution in the State of Wisconsin was born of necessity as far as the enforcement agency was concerned. The early years of pollution control activity in the state were supported by quite inadequate budgets for the program necessary. Intelligent pollution control enforcement required knowledge of stream conditions which could not be adequately obtained. At the same time, the pulp and paper industry comprising 34 paper mills, 15 sulfite pulp mills, and 3 sulfate pulp mills, as major paper and pulp interests in the state, were involved at an early date as principal sources of water pollution.

It is to the credit of both industry and government officials alike that those responsible foresaw at an early date the advantage of cooperative effort in attacking this problem. This joint action formed the basis of mutual understanding and consideration which has extended to the present time. The early pioneering work of such men as L. F. Warrick, State Sanitary Engineer at that time, and H. A. Rothchild and J. M. Conway of the pulp and paper industry, set the stage in Wisconsin for the present state of development of state-industry cooperation.

The development of the Sulphite Pulp Manufacturers' Research League, including membership of all but two sulfite pulp mills in the state, and the Advisory Committee on Waste Disposal of the Wisconsin Pulp and Paper Industry representing the great majority of the industry in the state, furnished representative and authoritative industrial agencies with which the state agency could work. The desirability of having some group or committee representative of a large industrial interest, or of planning cooperative work with a responsible and interested representative of a single industrial plant to guide the industrial participation in any cooperative agreement, is of prime importance.

Cooperative Industry Survey Work

Sampling

As the cooperative stream survey program now operates in Wisconsin, 15 mills participate in a weekly sampling program carried out on seven rivers of the state over sections of those streams in which the mills have an immediate interest. The program furnishes data obtained from approximately 765 samples taken at 45 sampling points. Some mills, relatively isolated from other pulp and paper sources, sample the entire reach of stream which may be affected by mill wastes. Ordinarily, this consists of one sampling point above the mill, with samplings at selected stations downstream extending into the recovery zone. In other cases where mills are more closely grouped, selected mills take the initiative in a joint program, sampling at stations which cover a reach of stream receiving wastes from several mill sources, with consequent division of the work load.

For example, on one stretch of stream 38 miles in length, there are 18 paper mills, 4 sulfite, 1 sulfate, 1 semi-chemical, and 1 groundwood pulp mill. The stream is sampled over the 38-mile distance at five stations by representatives of four mills. Where waste sources are grouped so closely on a receiving stream, bracketing of individual wastes becomes difficult, but by exercising proper care in selecting sampling stations it is possible to present a picture of total stream condition.

While good judgment and consideration of previously determined conditions may be used at first to establish sampling stations, trial and error will also be found of help in determining the most suitable points for investigation. Stations may be changed from

WISCONSIN STATE BOARD OF HEALTH, SECTION ON ENVIRONMENTAL SANITATION
STREAM SURVEY DATA

Laboratory _____ River _____ Date Collected _____

Days Incubated _____ Titration of Dilution Water After Incubation ml. _____ Corrected D.O. p.p.m. _____ =W

Temperature of Incubation _____ °C. Thiosulfate Standardization: 10 cc $K_2Cr_2O_7$ = _____ cc Thio. Factor = 10 / cc Thio. = =F

Location of Sampling Point	Water Temp. °C	pH	D. O. DETERMINATION: Initial Titration ml.	D. O. DETERMINATION: Corrected p.p.m.	D. O. DETERMINATION: % Saturation	Weather Water Observations	B.O.D. DETERMINATION: Bottle No.	B.O.D. DETERMINATION: Bottle Vol. ml.	B.O.D. DETERMINATION: Vol. of Sample Added ml.	B.O.D. DETERMINATION: 5 Day Titration ml.	B.O.D. DETERMINATION: Corr. 5 Day D.O. p.p.m.	Dilution Factor	5 Day B.O.D. p.p.m.
			(A)	(FxA) (S)				C	D	(B)	(FxB) (M)	C/D	

B.O.D. = (W-M) x C/D — (W-S)

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Analyst

Wpe - 1M - 1-56

FIGURE 1.—Data sheet used by industry to record sampling data.

time to time as the need dictates. Changes in mill processes, production, stream flow characteristics, seasonal water temperatures, or development of dams providing storage and changing the time-distance relationship may be reasons for change of station location.

Equipment and Personnel

The cooperative program now operating brings each participating mill into individual contact with the state water pollution control agency. As an initial contribution, the state supplied all field equipment necessary for sampling and the laboratory glassware needed for selected analyses. Necessary reagents, as well as equipment replacement items, are supplied annually to each mill prior to the start of the survey period which extends from the first week in June to the last week in September.

An instruction sheet is furnished which details the sampling technique and analyses for determinations of stream temperature, dissolved oxygen, 5-day B.O.D., and stream discharge. Stream flow is often determined by the rated wheel capacity of hydroelectric developments within the stretch of stream being surveyed. In other cases, daily flow data are obtained through the cooperation of the state office of the U. S. Geological Survey.

The participating mill furnishes both field and laboratory technicians for completion of the work. In some cases, one person fills both jobs, collecting samples, performing field tests, and carrying through the laboratory phase on returning to the mill. The mill also provides laboratory space for the analytical work consisting of perhaps one section of a laboratory table in the mill control or research laboratories. Constant temperature incubation facilities are also required at the mill for completion of the B.O.D. determination.

Supervision of industry personnel in the field and laboratory phase of the joint project is desirable. Whereas in some cases persons assigned to the project for the summer period may have had previous years of survey ex-

perience, it is as likely that temporary summer help may also be assigned such as undergraduate college students, or persons having technical training in industrial procedures but little concept of the limiting factors involved in this phase of endeavor. It is necessary, therefore, that periodic contacts be made with the cooperating industry to assure that field and laboratory procedures are carried out properly. The data obtained are no better than the attention given to their collection.

Temperature, pH, dissolved oxygen, and 5-day B.O.D. data are tabulated by the industry on form sheets developed for this purpose (Figure 1), and forwarded to the state committee on water pollution at the end of each survey month. The column headings used furnish the necessary data to make possible a recheck of all calculations.

Reporting Data

Upon completion of a summer period of survey work, all data are tabulated in the form which may be most useful to the interested parties. The maximum and minimum values determined might be used with maximum and minimum flow values. A typical summary sheet covering this approach is shown in Figure 2.

Calculation of stream loading may be attempted but it is not recommended in view of the limited data. The data, from the control agency standpoint, present a picture of stream conditions which would not be available without such cooperative effort. From the individual mill standpoint, the data furnish information pertinent to conditions which may be created in the stream by mill waste loading over a reach of stream in which the mill is particularly interested. The joint consideration of such survey results by all parties concerned, develops a mutual respect and understanding of problems facing the industry and the enforcement agency. In Wisconsin, the Advisory Committee on Waste Disposal of the Wisconsin Pulp and Paper Industry, in an annual joint meeting with representatives of the state agency, goes over the findings of the survey prior to release of the information to all member mills.

SUMMARY OF RESULTS OF COOPERATIVE STREAM SURVEYS
June - September, 1955

Stations	Discharge c.f.s. Maximum		Discharge c.f.s. Minimum		Miles	Dissolved Oxygen p.p.m. Maximum			Dissolved Oxygen p.p.m. Minimum			5-Day B.O.D. p.p.m. Maximum			Temperature Range °C		
	1953	1954	1955	1953 1954 1955		1953	1954	1955	1953	1954	1955	1953	1954	1955	1953	1954	1955
Chippewa River																	
Cornell	17250	23050	5691	1670 1170 1902	0.0	7.7	8.3	7.8	5.4	5.8	5.3	2.1	2.7	2.6	18-23	19-24	17.8-26.7
Cobban					5.0	7.5	8.8	8.6	5.4	5.8	5.6	2.2	2.8	2.2	19-23	19-25	17.8-27.2
Dells Dam	20300	27820		594 510	42.3	7.6	8.8	8.2	5.9	6.1	6.3	8.5	6.8	9.8	20-25	15-27	18.0-27.5
Milwaukee R.R. Br.					45.3	7.9	9.2	8.9	6.4	5.6	6.0	6.2	10.0	11.2	20-25	15-26	18.5-27.5
Shawtown Br.					46.3	8.2	9.0	8.5	6.6	5.8	6.4	5.7	8.4	10.3	20-25	16-27	18.0-27.5
Flambeau River																	
Mill Dam	2200	1710	893	830 546 394	0.0	8.6	8.1	7.8	5.7	6.2	4.1	3.3	3.9	2.9	13-25	12-24	13.5-25.5
Lower Dam					1.5	8.2	8.3	6.6	4.3	4.7	2.4	12.0	12.4	12.8	13-25	12-24	13.0-25.5
Highway 'B' Br.					3.0	8.1	8.4	6.3	3.8	4.2	1.4	12.2	13.1	14.4	12-25	11-24	12.5-25.5
Pixley Dam					6.2	7.2	7.6	5.5	2.7	2.8	0.5	8.3	9.1	11.9	12-25	12-25	13.0-25.5
Crowley Dam					11.5	7.2	7.0	5.4	1.2	0.9	0.1	5.8	6.9	8.2	13-25	12-25	13.0-26.0
Fox River																	
Neenah Channel					0.0	11.0	11.0	9.9	6.6	4.3	5.9	130*	175*	14.4	15-26	16-25	15.0-28.0
Kaukauna					13.5	4.8	5.4	6.2	0.0	0.0	0.0	16.6	16.9	18.5	16-26	15-28	15.5-28.0
Wrightstown	3510	5530	5900	1650 1620 1190	20.0	1.6	6.1	6.5	0.0	0.0	0.0	14.8	13.8	20.5	15-26	14-27	15.5-27.5
De Pere Dam					29.0	7.9	8.2	9.1	0.2	0.0	0.0	9.1	20.7	9.1	17-28	16-27	16.5-28.5
G.B. & W.R.R. Br.					35.0	4.2	7.7	-	0.0	0.0	0.0	242.8	17.7	22.4	18-26	18-27	16.5-28.0
Menominee River																	
No. 1 Niagara	15300	6690	5170	1100 826 733	0.0	9.0	9.4	9.5	5.8	3.4	4.9	2.3	4.5	5.8	12-24	12-23	14.5-25.0
No. 2 Niagara					1.0	10.0	9.0	10.2	4.1	2.9	2.4	21.9	27.8	29.8	11-24	13-24	15.0-26.0
No. 3 Niagara					5.0	9.3	9.6	9.8	6.8	5.7	5.1	8.8	13.8	13.9	11-24	12-24	15.0-26.0
Marinette Upper Dam	23800	-	7750	1800 - 1280	86.4	8.9	8.3	8.7	6.1	5.9	5.5	3.0	1.8	3.3	15-24	13-26	15.0-28.0
Marinette Lower Dam					87.6	9.6	9.1	8.4	5.8	4.7	4.6	7.1	14.3	11.5	15-24	13-26	15.0-28.0
Highway '41' Bridge					90.0	8.3	8.8	8.3	5.4	4.0	3.5	6.9	7.2	6.2	15-24	13-26	15.5-28.0
Oconto River																	
Oconto Falls	848	1100	668	247 231 185	0.0	9.3	8.4	8.6	5.9	5.9	4.4	1.3	2.7	2.1	15-26	14-26	14.5-26.5
Stiles					7.0	3.5	5.1	3.8	0.0	0.2	0.0	23.5	17.8	21.5	15-27	14-26	15.5-27.0
Peshtigo River																	
City Bridge	1569	1610	1510	7 7 120	0.0	8.8	8.8	9.1	6.7	5.6	5.6	12.7	14.5	22.6	14-29	12-25	14.0-27.0
One Mile Below					1.0	4.1	5.8	9.5	4.1	5.8	5.2	15.1	16.6	23.3	14-29	11-25	14.0-27.0
One Mile from Bay					7.0	0.1	0.0	7.0	0.1	0.0	0.2	16.7	17.5	20.6	14-29	12-26	15.0-27.0

* High B.O.D. value is due to large quantities of algae

FIGURE 2.—Typical summary sheet for comparing maximum and minimum values.

Cost and Evaluation

While the collective project represents considerable effort, only a small amount of travel is involved and continuing costs in equipment and supplies are small. Costs to the industry involve principally the time of one man about one day per week.

Due to the number of samples obtained and the period of sampling, which covers critical stream flows and water temperatures, surveys of this type furnish worthwhile information as to general stream conditions. The accumulated data become limited, however, in arriving at any justified evaluation of stream improvement requirements and must be considered as qualitative data.

Special Survey Work

To obtain adequate information of the type needed to more accurately determine the degree of pollution abatement required, the sulfite pulp industry, through representation of the Sulphite Pulp Manufacturers' Research League in cooperation with the Wisconsin State Committee on Water Pollution, carries out more intensive survey work on critical reaches of streams in the state to obtain quantitative stream pollution information.

The mechanics of the survey are set forth here as a further step in aiding those interested in developing cooperative industry-government agency surveys. The detail is necessarily restricted to stream surveys involving flowing waters but is partially applicable, through modification, to relatively static water bodies receiving significant waste loadings.

Any survey procedure which intends to furnish information valuable and pertinent to determining load-assimilation factors is never complete in all aspects, as the practical requirements of the program soon become apparent. Physical limitations placed on sampling and analyses of samples and data govern the survey procedure. The program must then develop from a simultaneous consideration of personnel needs, equipment, and facilities available, as against the extent of investigation possible and desirable. These considerations and limitations determined the procedure followed in the various surveys.

Data

The basic data which appeared necessary for a program of this type, for the purposes intended, included the determination of stream discharge, 5-day B.O.D., ultimate B.O.D., dissolved oxygen, temperature, pH, and suspended solids, both fixed and volatile. With such information obtained on individual stations through multiple samplings at the station cross sections, it was possible to arrive more precisely at a quantitative measure of stream loading, waste distribution, solids added and deposited, reaeration, and oxygen utilization values. Basic information of this type was expected to make possible the more exact prediction of the working capacity of the stream. Eventually it should be possible, with due allowance for considered judgment, to determine the relative degree of waste loading reduction required under critical flow-temperature conditions.

Station Location

To collect the information, it was necessary that stations be established both above and below sources of waste. Selection of these stations was governed by consideration of stream flow characteristics in the cross section to be used, as well as distance above and below the source of waste under consideration. However, practical limitations involving accessibility, time, manpower, handling of equipment, and transportation of samples also governed the selection. Standard operating procedure for a survey of this type involved the division of the stream at the selected stations into 20 sections,

from right to left looking downstream, for gaging and sampling. This basic 20-section per station plan was utilized at all stream stations irrespective of stream width.

Three methods of dividing each station into 20 sections and locating the gaging and sampling points were used. These included the use of a cable, convenient bridge, or stadia for positioning the sampling equipment.

Where navigation and width of stream are not controlling factors, use of a tag line similar to that employed by the U. S. Geological Survey is most practical. The tag line employed was a galvanized steel, 7 by 7 construction cable.* Although a 3/32-in. cable, having a breaking strength of 920 lb. was satisfactory for short stream widths up to several hundred feet and without high velocity currents, a 1/8-in. diameter, 1,700-lb. breaking strength cable is recommended for use under high velocity conditions and at river stations where the strand must be extended more than 300 ft. The cable can be marked with single lead-soldered beads at 10-ft. intervals, double beads at 50-ft. intervals, and triple beads at 100-ft. intervals. Under usual conditions, such a calibrated cable can be used to locate easily the individual gaging and sampling points. A block and tackle and come-a-long clamp for pulling the cable into position are necessary.

The method used to run out the strand from the reel, anchor the cable, and draw it into position is dependent on experience and circumstances, and no one substitute or explanation fits all occasions. With the cable at right angles to the stream flow, the boat is positioned pointing into the current and the cable locked in place at the port and starboard bow. The use of the cable is facilitated by employing the standard boat boom used by the U. S. Geological Survey which provides facilities for holding the cable, suspending the meter, and mounting the sounding reel.

Stations may be established at bridges providing certain precautions are taken to avoid large errors in flow measurement. The cross section in this case takes the form of an arc, midstream measurements being taken 75 to 100 ft. below the bridge to avoid interference by piers. The boat can be guided by a rope from the bridge located at the 20 designated points marked out on the bridge structure, but it should be anchored off the stern, with the bow rope pulled tight to avoid objectionable current and wind movements of the boat. When employing a rigging of this type, it is advantageous to construct a yoke arrangement of the lead ropes from the bow with one lead from both the port and starboard sides. The yoke so formed encloses the bow of the boat and the boat boom assembly. A single lead line from the apex of the triangle thus formed secures the boat to the bridge structure.

Where suitable bridges are not available and where navigation becomes a limiting factor with the result that the use of a cable becomes a hazard, a transit and stadia rod may be employed to position the boat containing gaging and sampling equipment. The stadia rod, mounted by clamping upright in the boat, enables the transit man by suitable signal to position the boat at predetermined section limits, as computed by dividing the total stream width into the desired 20 sections.

The positioning of the boat is not easily accomplished by this method, although an error of several feet at any position can be compensated for at the following section. However, as the actual determined section width is used in flow measurement computations, no significant error results from this procedure. Current and wind exert considerably more influence over

* Air cord, John A. Roebling's Sons Co., Trenton, N. J.

the anchored position than when the boat is clamped to the cable, or when it is secured by a rope attached to a bridge. Use of two anchors off the forequarter points of the boat, or quartering bow and stern, usually control this effect except under extremely adverse conditions. It is obviously necessary that the boat be maintained as closely positioned as possible to allow for accurate gaging and sampling. Where distinguishing land marks for alignment are lacking, range poles should be employed.

Survey Craft

Two different boat units were employed for the survey period. The use of a sufficiently large boat for apparatus and sample cases, with room for some movement of two or three men is necessary. The majority of the survey work from a single boat unit was done from a Reynolds aluminum 12-ft. rowboat having a 54-in. beam, upturned bow, and broad, rounded forward dimensions. This type of craft is especially suitable, as the large flatbottom area is available for holding equipment and cases, while the displacement and stability characteristics provide safe working conditions.

A second assembly developed by joining two canoes in catamaran style was also employed for extensive work. Three bracing pieces were clamped across the canoes at the gunnels positioning the craft parallel to each other and about 8 in. apart at the midship point. The back bracket carried the motor mounting board between the canoes. This assembly was extremely seaworthy and mobile.

Gaging measurements were made at each of the 20 sections by use of a standard current meter, suspended from a boat boom which also mounted the sounding reel. All equipment employed was similar to standard U. S. Geological Survey stream gaging apparatus.

Personnel

Consideration of the several job categories into which gaging and sampling work could be divided indicated the need for three workers in any field crew. The work divides itself into:

1. Stream gaging.
2. Field calculations and transit work, where a transit is used.
3. Sampling and motor operation for boat positioning.

With this division of work, the best utilization of the available manpower was obtained. While some lags occur and the synchronization of activities is not entirely ideal, experience indicates that less time is wasted by this division of the field load. A single field crew of three cannot reasonably cover more than two cross sections per day. While the actual gaging and sampling time per station requires 2.5 to 3 hr., the movement of equipment, the setup and pickup add several hours. In addition, delaying and annoying problems develop in a majority of cases, usually resulting in a 10- to 12-hr. day for a field crew to cover the two stations.

The size of the laboratory staff is dependent on the work load coming from the field. Experience indicated that two laboratory workers are needed per field crew. When the number of workers in the laboratory fell below this level troubles developed, resulting in unusually long hours of work for those involved. The use of two field crews sampling at the same time results in a proportional increase in the laboratory staff.

Job assignment in the laboratory and field crews is desirable so that personnel involved become experienced. Once a survey covering multiple stations is started, the program must be carried through prior to possible radical changes in stream discharge. It is a definite asset to have each field and laboratory staff member thoroughly familiar with his job under adverse working conditions, which may

be brought on by abrupt weather changes. In addition, and to facilitate field and laboratory work, it is desirable that one additional man be available for transporting samples to the laboratory and supplies to the field.

Survey Techniques

Gaging measurements were made in each section at the 0.2 and 0.8 depth, giving a total of 40 discharge measurements at any station. The gaging procedure followed that used by the U. S. Geological Survey. The sampling of the stream was carried out at the odd numbered section limits at the 0.2 and 0.8 depths, *i.e.*, Sections 1, 3, 5, 7, etc., giving a total of 20 cross-section samples. Samples were obtained by use of a Kemmerer sampler. Three sample bottles consisting of water samples for (a) B.O.D., (b) dissolved oxygen, and (c) pH, deoxygenation rates, and suspended solids were collected. Accordingly, 60 sample bottles per cross section were necessary.

The B.O.D. samples were iced immediately after collection by submergence in an ice-water bath, thus providing cooling and preventing contraction from drawing air into the bottle. Dissolved oxygen samples were fixed in the field, titration of the D.O. samples being carried out in the laboratory. Temperature values were also necessarily determined at the time of sampling. The pH value of individual samples was determined in the laboratory on the third sample bottle which was also used for compositing for solids analyses and determination of deoxygenation rates.

Sample bottles used in the field were labeled to correspond to the sample contained using a code to designate the exact station, section, and stream depth. Thus, V15B, designated Station 5, Section 15 at the 0.8 depth, while III7A, denoted Station 3, Section 7 at the 0.2 depth.

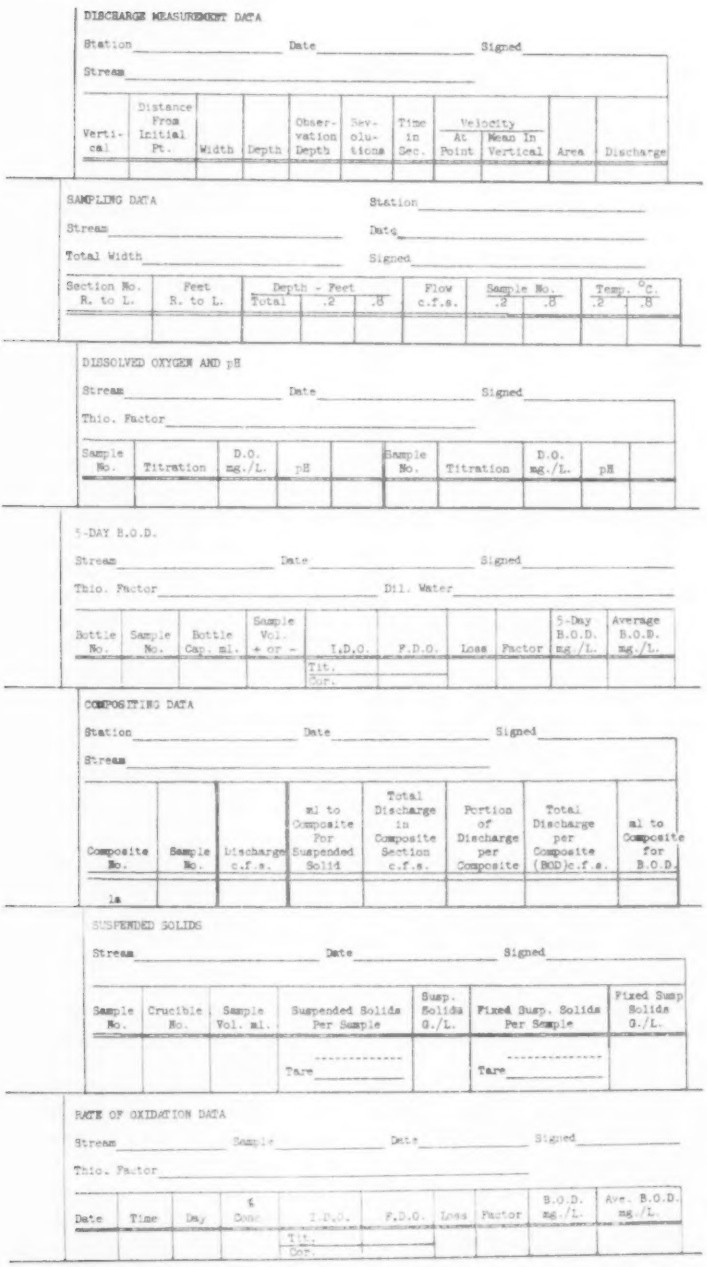
The analyses of samples followed those methods set forth in "Standard Methods," supplemented dilution water being used for the B.O.D. work. Two dilutions were made for each B.O.D. determination, resulting in 40 samples per station, exclusive of blanks. Incubation facilities consisting of stock-watering tanks filled with circulating temperature-controlled water performed most satisfactorily in handling up to 400 B.O.D. bottles.

The problem of separate suspended solids analyses of individual samples becomes a physical impossibility in consideration of any reasonable laboratory program supporting a survey of this type. Accordingly, solids samples were composited on the basis of discharge at the upper and lower levels in each of three sections. This required a composite of Stations 1, 3, 5; 7, 9, 11, 13; and 15, 17, 19. The result was six solids determinations per station, or as the cooperative program developed throughout the summer, a maximum of 54 solids analyses for the largest survey effort involving 9 stations on one stream.

Data Sheets

The development of adequate means and methods for maintaining suitable records is most important. A record sheet devoted to each separate field activity and laboratory analysis gives maximum flexibility in carrying out the mechanics of the survey. A total of seven separate and distinct forms were used during completion of the sampling and analytical work. All forms were duplicated on 8½ by 11 paper to facilitate handling and later combination into the basic survey data collection. Field forms covering (a) discharge measurement data and (b) sampling data were employed by the field crews.

The discharge measurement form, recording all readings associated with determination of stream discharge, was copied from the U. S. Geological Survey stream discharge survey form with the use of Standard U.S.G.S.



DISCHARGE MEASUREMENT DATA

Station _____ Date _____ Signed _____

Stream _____

Vertical	Distance From Initial Pt.	Width	Depth	Observation Depth	Revolutions	Time in Sec.	Velocity At Point	Velocity Mean In Vertical	Area	Discharge

SAMPLING DATA

Station _____

Stream _____ Date _____

Total Width _____ Signed _____

Section No. R. to L.	Feet R. to L.	Depth - Feet Total	.2	.8	Flow c.f.s.	Sample No. .2	.8	Temp. °C. .2	.8

DISSOLVED OXYGEN AND pH

Stream _____ Date _____ Signed _____

Thio. Factor _____

Sample No.	Titration	D.O. mg./L.	pH		Sample No.	Titration	D.O. mg./L.	pH	

5-DAY B.O.D.

Stream _____ Date _____ Signed _____

Thio. Factor _____ Dil. Water _____

Bottle No.	Sample No.	Bottle Cap. ml.	Sample Vol. + or -	I.D.O.	F.D.O.	Loss	Factor	5-Day B.O.D. mg./L.	Average B.O.D. mg./L.
				Tit.					
				Cor.					

COMPOSITING DATA

Station _____ Date _____ Signed _____

Stream _____

Composite No.	Sample No.	Discharge c.f.s.	ml to Composite Per Suspended Solid	Total Discharge in Composite Section c.f.s.	Portion of Discharge per Composite	Total Discharge per Composite (BOD) c.f.s.	ml to Composite for B.O.D.
1a							

SUSPENDED SOLIDS

Stream _____ Date _____ Signed _____

Sample No.	Crucible No.	Sample Vol. ml.	Suspended Solids Per Sample	Susp. Solids G./L.	Fixed Susp. Solids Per Sample	Fixed Susp Solids G./L.
			----------		----------	
			Tare _____		Tare _____	

RATE OF OXIDATION DATA

Stream _____ Sample _____ Date _____ Signed _____

Thio. Factor _____

Date	Time	Day	% Cons.	I.D.O.	F.D.O.	Loss	Factor	B.O.D. mg./L.	Ave. B.O.D. mg./L.
				Tit.					
				Cor.					

FIGURE 3.—Sample headings of the seven forms used for field and laboratory data.

Oconto River Station No. 1 Mill Headrace A.M. July 13, 1955

Vertical			Flow c.f.s.		T°C		pH		Dissolved Oxygen							5-day B.O.D.						Ult.B.O.D.
									p.p.m. depth		% Sat. depth		#/day/sample section depth			p.p.m. depth		#/day/sample section depth				
No.	Ft/ sect.	Feet depth	per sect.	per empl. sect.	depth .2	depth .8	depth .2	depth .8	.2	.8	.2	.8	.2	.8	Total	.2	.8	.2	.8	Total	#/day *
1.	20.5	2.0	2	12	25.0		8.2		6.72		80		240	192	432	1.4		48	48	96	224
2.	13.0	4.3	10																		
3.	13.0	5.7	17	38	25.0	24.5	8.2	8.2	7.12	6.92	85	82	888	552	1440	1.3	1.3	168	96	264	616
4.	13.0	5.7	21																		
5.	13.0	5.8	21	39	24.8	24.5	8.2	8.2	6.87	7.07	81	83	840	600	1440	1.2	1.4	144	120	264	616
6.	13.0	5.3	18																		
7.	13.0	5.8	19	41	24.8	24.7	8.2	8.2	6.97	6.87	82	80	936	600	1536	1.4	1.3	192	120	312	728
8.	13.0	5.8	22																		
9.	13.0	6.2	23	46	25.0	24.8	8.2	8.2	6.97	6.97	83	83	1056	672	1728	1.5	1.4	240	144	384	896
10.	13.0	6.2	23																		
11.	13.0	6.3	23	42	25.0	24.9	8.3	8.2	6.97	6.92	83	82	936	624	1560	1.3	1.4	168	120	288	672
12.	13.0	6.3	19																		
13.	13.0	6.3	17	36	25.5	24.9	8.2	8.2	6.82	6.77	81	80	816	504	1320	1.2	1.4	144	96	240	560
14.	13.0	6.2	19																		
15.	13.0	6.2	19	38	25.6	25.0	8.2	8.2	6.82	6.77	82	80	840	552	1392	1.3	1.4	168	120	288	672
16.	13.0	6.0	19																		
17.	13.0	5.5	20	40	25.5	24.9	8.1	8.2	6.72	6.87	80	81	864	600	1464	1.3	1.3	168	120	288	672
18.	13.0	5.2	20																		
19.	13.0	2.8	14	19	25.0		8.2		7.37		87		432	312	744	1.2		48	72	120	280
20.	20.5	0.0	5																		
Total Ave.	275.0		351	351	25.1	24.8	8.2	8.2	6.91	6.88	82	81	7848	5208	13056	1.3	1.4	1488	1056	2544	5936

Total Suspended Solids						
		p.p.m. depth		#/day/sample section depth		
Sect. No.	cfs	.2	.8	.2	.8	Total
1.	89	5.8	4.4	1656	864	2520
2.	164	6.2	3.2	3288	1152	4440
3.	98	5.4	5.0	1752	1056	2808
Total	351			6696	3072	9768

Fixed Suspended Solids						
		p.p.m. depth		#/day/sample section depth		
Sect. No.	cfs	.2	.8	.2	.8	Total
1.	89	3.2	2.6	912	504	1416
2.	164	3.4	1.6	1800	576	2376
3.	98	3.2	2.4	1008	504	1512
Total	351			3720	1584	5304

*Based on a k factor of .0486; 5 day B.O.D. equals 42.88% of Ultimate.

FIGURE 4.—Stream survey data summary sheet.

technique and procedure in arriving at increment and total discharge.

The sampling data form was used to tabulate the essential values taken from the discharge record for compositing purposes, and also contained columns for temperature values.

All field records were maintained in duplicate on clipboards; the carbon copy accompanied each set of samples to the laboratory. As compositing was carried out on the basis of stream discharge in the three sections previously mentioned, samples were usually submitted to the laboratory in this grouping with all flow data completed to accompany the samples.

Laboratory forms covering the individual analyses were maintained by the laboratory staff. The coding previously mentioned for identification of any field sample was also employed in laboratory records. Forms for (a) dissolved oxygen and pH, (b) 5-day B.O.D., (c) compositing data, (d) suspended solids, and (e) rate of oxidation data, adequately covered the information to be recorded. Sample headings of all forms used are shown in Figure 3. These data were also recorded in duplicate. At the conclusion of the necessary calculations, the two cooperating agencies each received a copy of all original data.

The basic data summary sheet for any one station may take a number of forms, depending on expected later use. The basic data tabulation shown in Figure 4 was developed as the one best suiting the needs for presentation of pertinent values derived from the survey.

Conclusion

Cooperative efforts of this type of study provide a working relationship between industry and government which is valuable to both. Also, information concerning stream conditions is much more complete, and in greater detail, covering more of the variable factors than would otherwise be available to either industry or government acting alone. In addition, from the stream utilization and purification standpoint, basic quantitative information must be obtained to make possible any rational approach to developing permissible loading factors.

Editor's Note—Additional information will be furnished gladly upon request to either the Wisconsin State Committee on Water Pollution, State Office Building, Madison, Wis., or the Sulphite Pulp Manufacturers' Research League, P. O. Box 436, Appleton, Wis.

HEBERT APPOINTED A DIRECTOR IN BDSA

Raymond E. Hebert, President of the Filtration Corporation, Rochester, N. Y., was appointed on January 16, 1957, as Director, Water and Sewerage Industry and Utilities Division, Business and Defense Services Administration, U. S. Department of Commerce. Mr. Hebert is on loan from his corporation for a period of six months or longer under a rotation system whereby outstanding industrial executives serve the Government without compensation. Mr. Hebert succeeds Richard V. Ford, Vice-President and Export Manager of the Ford Meter Box Company.

THE OPERATOR'S CORNER

CONDUCTED BY DONALD P. SCHIESSWOHL

PREVENTIVE MAINTENANCE OF AIR FORCE SEWAGE WORKS *

BY HAROLD A. PFREIMER

Chief, Sanitary Engineering Section, Directorate of Facilities Support, Headquarters, U. S. Air Force, Washington, D. C.

Effective maintenance of sewage treatment equipment and plant facilities is recognized as important as proper design and construction of the plant.

In 1957 the United States Air Force will have about 350 operational bases supported by almost 2,000 lesser installations of all types, both in the continental United States and overseas. Maintaining and operating this physical plant is a tremendous task.

Sewage works facilities at Air Force installations are similar to and present the same requirements and problems as those at municipalities. The day that construction is finished, deterioration begins and maintenance personnel must go to work. Annual expenditures for maintaining sewage works presently amount to about 4¼ million dollars or 2¾ per cent of their capital replacement value. It would be an impossible task to effectively control and assure the maintenance of these scattered facilities, existing under widely varying geographical and climatic conditions, without some standard system or procedure for keeping structures and equipment in good condition. The establishment of a uniform program of preventive maintenance has been found to be the best means of attaining this goal.

Preventive maintenance is a planned and scheduled operation designed to minimize deterioration and to detect and correct deficiencies on the spot. Essentially, it is nothing more than a method of keeping facilities in good condition by assigning specific people to specified tasks on a predetermined schedule. A preventive maintenance program corrects defects in the early stages before they develop into major repairs or replacements. It is a positive means of:

1. Insuring proper maintenance and preventing breakdowns.
2. Controlling maintenance costs.
3. Establishing specific personnel assignments.
4. Developing minimum adequate maintenance records and data.

A preventive maintenance program contains two elements, "detection and correction" or more simply "find it" and "fix it."

Program Phases

Preventive maintenance is nothing new. It has been used in the Air Force in one form or another for many years. Based on results of management studies made at a number of installations, the program was modified about a year ago to meet new

* Presented at 1956 Annual Meeting, Pennsylvania Sewage and Industrial Wastes Assn.; University Park, Pa.; Aug. 29–31, 1956.

requirements and to more aggressively pursue its objective. Under this program preventive maintenance of sewage works facilities is carried out in two separate phases.

Zone Building Maintenance

Each base is divided into maintenance zones consisting of from 50 to 200 buildings, depending on the size of the base, the type of buildings, and local conditions. Trained maintenance crews consisting of personnel skilled in carpentry, plumbing, heating, electrical work, painting, glazing, and roofing inspect each building in the zone at least once every 90 days. These crews, working under zone supervisors, are equipped with the proper tools and adequate repair parts and perform on-the-spot repairs and servicing. This phase of the program assures that treatment plants, pumping stations and other plant buildings obtain a complete inspection and servicing at least every 90 days.

Equipment Maintenance

The second phase is carried out by sewage plant personnel working under the direction of the plant supervisor. It consists of the continuous maintenance of all units and each piece of equipment in the plant through inspecting, cleaning, lubricatting, and servicing on a scheduled basis.

To meet minimum standards of proficiency, operators are given field training by the plant supervisor and sanitary engineers of the various Air Force major commands in proper operating practices and maintenance procedures. They are given formal schooling through special courses conducted by the U. S. Public Health Service and are encouraged to attend short courses and local sewage and industrial wastes conferences.

The zone preventive maintenance crew maintains the buildings and structures of the sewage works, leaving plant personnel free for operational duties and for maintenance of the specialized equipment and treatment units. Where the work required is beyond the capability or responsibility of the zone crew or plant personnel, it is performed by the various installation engineer maintenance shops which are available for all major repair work either in or out of the plant.

Manuals

The technical aspects of establishing a program and scheduling, executing, and recording specific phases of preventive maintenance by the operator are contained in technical manuals. These are designed to assist personnel in keeping equipment in good condition and in detecting and correcting unsatisfactory conditions. The manuals contain guide instructions on how to inspect, clean, service, lubricate and adjust equipment, and how to keep prescribed maintenance records. Data in the manual are based on recognized commercial practices and manufacturers' equipment instructions.

Systematic inspection and servicing of each piece of equipment are the basic requirements of a good preventive maintenance program. As part of his responsibility for these activities, the operator is required to keep records for each piece of equipment.

Figure 1 shows a typical page from the manual "Maintenance and Operation of Sewage and Industrial Waste Plants and Systems," which is presently under preparation. On the right-hand side of the page are specific step-by-step instructions for each operation in the inspection and service procedure for the equipment designated. On the left-hand side of the page are columns indicating the frequency of action required for each operation. The item numbers listed under the frequency columns are used merely to simplify the recording of the maintenance data.

D	W	M	Q	S	A	
						G6.06 **COMMINUTORS**
23						a. **Lubricate Lower Shaft Bearing.** Proper lubrication protects lower shaft bearing and prevents sewage from penetrating to bearing through lower oil seal. (See No. 17, Fig. 159.) Lubricate with GAA grease in winter and CG1 in summer, added through the grease fitting. (See No. 9, Fig. 159.) After lubricating, replace waterproof cap on grease fitting. Amount of grease depends on type of comminutor as follows: (1) 7B comminutors: 12 strokes of grease gun, $\frac{1}{6}$ ounce. (2) 10A comminutors: 12 strokes of grease gun, $\frac{1}{6}$ ounce. (3) 15M and 25M comminutors: 18 strokes of grease gun, $\frac{1}{4}$ ounce. (4) 25A comminutor: 24 strokes of grease gun, $\frac{1}{2}$ ounce. (5) 36A comminutor: 30 strokes of grease gun, $\frac{3}{5}$ ounce.
						FIGURE 159. CROSS SECTION, COMMINUTOR
	26					b. **Check Oil Level in Gear Reducer.** Add oil as required to fill to oil-level mark. For atmospheric temperatures from 10°F to 32°F, use 2190; from 32°F to 70°F, use 3050; from 70°F to 130°F, use 3065. NOTE: Shaft-extension universal joints and spline require no lubrication.
					31	c. **Check Operating Limits.** Control storm flows to prevent sewage from rising above top of bearing housing. See that normal dry-weather fluctuations in sewage level at comminutor do not rise higher than the following: (1). For 7B, 10A, 15M, and 25M comminutors, 10 inches above top of drum. (See No. 23, Fig. 159.) (2). For 25A and 36A comminutors, 15 inches above top of drum.
	27					d. **Lubricate Submerged Bearings.** If storm flows or other fluctuations of flow cannot be controlled to limits given above, install automatic lubricator to keep comminutor continuously lubricated and to protect submerged bearings.
	28					e. **Inspect and Service Comminutor Assembly.** Clean comminutor basin as necessary and inspect working parts of comminutor. Also inspect comminutor immediately after any abnormal flow due to storms and sewer flushing. For this inspection drain comminutor basin and the approach channel if possible and wash comminutor and basin clean with a hose.
24						f. **Remove Grit.** Flush thoroughly with a hose to remove grit from bottom of comminutor chamber.
25						g. **Clean Comb.** To clean comb, run a stock of wood up and down cutting edges as comminutor rotates.
		30				h. **Inspect Cutting Edges.** Examine each cutter and replace if dull. (See Fig. 160.) Inspect shear bars and replace those with a. . . . .

FIGURE 1.—Typical page from U.S. Air Force sewage treatment plant maintenance and operation manual. Column headings indicate frequency of maintenance operation, daily, weekly, monthly, quarterly, semi-annually and annually.

Records

Figure 2 shows the preventive maintenance check list which is used for recording the appropriate inspection or service required for each piece of equipment. Data such as item number, preventive maintenance service, manual reference and frequency are

transcribed to the form from the technical manual.

Figure 3 shows the preventive maintenance service record which indicates when and by whom the maintenance work was performed, the number of manhours used, and the essential equipment nameplate data. It is also used to note unusual conditions or items which are beyond the repair capability of the operator. These cards are reviewed daily by the plant supervisor, and, if the discrepancies are considered sufficiently serious, the necessary maintenance shops are notified and requested to make the repair.

Recording of data and keeping complete records of the work done is an essential part of the program. It insures the supervisor that personnel are carrying out their duties, provides a history of the physical condition and applicability of the equipment for the service required, and keeps the operator alert to his responsibilities. Once the check list has been prepared, the recording of work performed is a simple matter.

PREVENTIVE MAINTENANCE CHECK LIST — SHEET 4 OF 40

BOOK NO. 21 — AIR FORCE MANUAL 85-14

DESCRIPTION OF EQUIPMENT OR FACILITY

Bldg. No. 345, SEWAGE TREATMENT PLANT
COMMINUTOR

ITEM NO.	PREVENTIVE MAINTENANCE SERVICE	MANUAL REFERENCE	FREQUENCY
50,51	Check Motor	G2.01a&b	Daily
23	Lubricate lower shaft bearing	G6.06a.	"
24	Remove grit	" f.	"
25	Clean comb	" g.	"
26	Check oil level - gear reducer	" b.	(Monday) Weekly
27	Lubricate submerged bearings	" d.	"
28	Inspect & service comm. assembly	" e.	"
29	Inspect base seal	" i.	"
30	Inspect cutting edges	" h.	(1st Mon.) Monthly
31	Check operating limits	c.	(July) Annually

FIGURE 2.—Preventive maintenance check list.

PREVENTIVE MAINTENANCE SERVICE RECORD

CARD NO.	BOOK NO.	COST CODE NO.
6	21	

DESCRIPTION OF EQUIPMENT OR FACILITY (include building no.)
BUILDING No. 345, SEWAGE TREATMENT PLANT COMMINUTOR

AREA	ZONE	SUBZONE
	2	

LOCATION WITHIN STRUCTURE	IE NUMBER
SCREEN CHAMBER	

ESSENTIAL NOMENCLATURE

MANUFACTURER	CATALOGUE OR MODEL NO.
CHICAGO PUMP CO.	10A

SIZE (H.P., Kva., etc.)	SERIAL NO.	RPM
1/2	50-A9564	1750

OTHER PERTINENT DATA (belt size, refrigerant, etc.)
GEARHEAD MOTOR - WEATHERPROOF

DATE	MAN HOURS	PREVENTIVE MAINTENANCE ACCOMPLISHED	SIGNED
AUG. 6		50, 51, 24, 25, 26, 27, 28, 29, 30 O.K.	HaP
7		50, 51, 23, 24, 25 O.K.	HaP
8		" " " " " O.K.	HaP
9		" " " " " O.K.	HaP
		Broken grid member - requires shop repair	

FIGURE 3.—Preventive maintenance service record.

Conclusion

A sound preventive maintenance program requires:

1. Selection of qualified plant supervisors.
2. Training and instruction for all operators in proper operating procedures.
3. Systematic, scheduled inspection and servicing by designated personnel.

The program must be made flexible in order to perform maintenance of different types under a variety of conditions. Procedures must be variable in that certain facilities have permanently assigned operators while others require only periodic attendance.

Preventive maintenance programs, to be successful, must be aggressive and continuous. Diverting personnel from their duties to other work will result in a poorly executed program and subsequent deterioration of facilities. Taking personnel from assigned tasks should be permitted only in emergencies.

Executing a preventive maintenance program requires the exercise of care and sound judgment to insure that property is not over-maintained. This can result in the expenditure of funds in excess of replacement costs. Accordingly, careful analysis of manufacturer's maintenance specifications and local requirements is essential to determine proper maintenance levels. A proper level of maintenance is one which will merely hold the facility or equipment "in status quo."

The new Air Force preventive maintenance program has been in effect since September, 1955. The most important aspect of this program is that plant supervisors and operators are free to do the job they were hired to do; namely, operate the plant and maintain the specialized equipment and treatment plant units.

Certain improvements in field maintenance are already obvious. The daily complaint calls to the installations engineer have decreased, in many cases more than 50 per cent. Repair costs are being controlled and requirements for transportation are being reduced. Experience indicates that there is a minimum of confusion, personnel have better balanced work schedules, and work is being performed more effectively. However, most important is the fact that continuity of operation is being assured, treatment works are doing the job for which they were designed, and facilities are being kept in a condition ready for any emergency.

OKLAHOMA CITY'S SEWAGE TREATMENT PLANTS*

By Grover L. Morris

Sanitary Engineer and Superintendent, Sewage Treatment Division, Water Department, Oklahoma City, Okla.

Oklahoma City has grown rapidly since Statehood in 1907 when it had a population of 63,000 and an area of 15 square miles. In 1956 the population was 292,000 and the area within the corporate limits was 77 square miles. It is estimated that a population of 325,000 resides within the metropolitan area.

The city is located on the watershed of four major streams necessitating the construction of four separate sanitary sewerage systems. The North and Northwest areas of the city are located on the Deep Fork Creek watershed and are served by the 10 m.g.d. Northside activated sludge plant. The extreme Northern area is on the Cimmarron River watershed and is served by a collection system and lift station which discharges to the Deep Fork System. The Central and Southern areas are on the North Canadian River watershed and are served by the 25 m.g.d. Southside two-stage trickling filter plant. The extreme Southwest area is on the South Canadian River watershed and is served by the 0.8 m.g.d. Will Rogers Field single-stage trickling filter plant.

There are 12 other small plants in the vicinity of Oklahoma City serving a total of 33,000 persons.

This situation points up the need for consolidation of the sewage treatment facilities in the area. This may be accomplished by (a) annexation to the city, (b) formation of an all-inclusive sanitary district, or (c) development of facilities by contract agreements between the city and outlying areas.

At the present time such a program is restricted, due to Oklahoma State

* Presented at the 29th Annual Meeting, Federation of Sewage and Industrial Wastes Assns.; Los Angeles, Calif.; Oct. 8–11, 1956.

Constitutional Requirements pertaining to municipal financing. An effort is being made to amend the Constitution, after which the big job of promotion, planning, and financing can be accomplished. Consolidation would increase the over-all efficiency and reduce the per capita cost of sewage treatment in the area.

The Southside and Northside treatment plants serve the major population of the metropolitan area; therefore, the design and operation of these two plants will be discussed in some detail.

The Southside plant is a separate sludge digestion, two-stage trickling filter plant with recirculation provided for both the primary and secondary trickling filters. The raw sewage is comminuted and pumped to one of two 22-ft. square detritors which provide 0.9 min. detention. Primary settling is obtained through the use of four 114-ft. square clarifiers at a detention time of 1.87 hr. at 50 m.g.d. The four primary trickling filters are 166 ft. in diameter and 6 ft. deep. The loading is 4,330 lb. of B.O.D. per acre-foot per day at a volumetric loading of 25 m.g.d. Filter effluent is pumped to the secondary clarifiers and then flows by gravity to eight secondary trickling filters and four final rectangular settling tanks. The secondary filters are 186 ft. in diameter and 6 ft. deep. The organic loading is 416 lb. B.O.D. per acre foot per day at a volumetric loading of 5 m.g.a.d.

Sludge digestion takes place in six primary digesters and two secondary digesters. Drying beds and lagoons are used for handling the digested sludge.

The Northside plant is a separate sludge digestion, tapered aeration diffused air activated sludge plant.

The raw sewage is comminuted and the grit removed in two areation-type units. Three rectangular primary clarifiers provide 1.5 hr. detention at 10 m.g.d. The settled sewage flows by gravity to the eight aeration tanks. Tank dimensions are 140 ft. by 30 ft. by 15 ft. and provide 7 hr. of detention at a flow of 10 m.g.d. plus 2.5 m.g.d. of returned sludge. Four 70-ft. diameter final clarifiers settle the aeration tank effluent for 2 hr.

Two primary and two secondary digesters handle all the sludge. Drying beds and a lagoon are used for sludge drying.

The basis of design for the two plants is given in Table I.

The Northside plant is designed for an expected load of 10 m.g.d. of domestic sewage with a B.O.D. of 200 p.p.m., whereas, the Southside plant carries an industrial load comprising 60 per cent of the total plant load with a diluted B.O.D. of 375 p.p.m. The major industrial load is from the meat packing industry. There are

TABLE I.—Plant Design Data

Item	Southside Plant	Northside Plant
Contributing population (1950)	175,000	100,000
Equivalent population	460,000	100,000
Flow (m.g.d.):		
Average	25	10
Maximum	37.5	15
Minimum	10	3
B. O. D.:		
Raw (p.p.m.)	375	200
Raw (lb./day)	78,200	16,680
Suspended solids:		
Raw (p.p.m.)	500	375
Raw (lb./day)	104,250	31,275

TABLE II.—Average 1956 Loadings

Item	Southside Plant	Northside Plant
Contributing population	202,400	82,600
Equivalent population*	442,000	53,300
Raw sewage flow (m.g.d.)	23.30	6.35
B. O. D.:		
Raw (p.p.m.)	380	168
Raw (lb./day)	73,800	8,900
Suspended solids:		
Raw (p.p.m.)	350	174
Raw (lb./day)	68,000	9,215

* Based on 0.167 lb. per capita per day.

other loads of significance including wastes from the processing of milk and dairy products, commercial laundries, and food processing. Grinding of garbage with discharge into the sanitary sewers is permitted from residences only because the additional load from commercial establishments on the plant digesters would be too great for the present plant digesters to handle.

A comparison of the original design load (Table I) with the average 1956 load on the plants (Table II) shows that the plants are presently approaching load capacity, when consideration is given to the flow volume and organic concentration.

Secondary treatment usually requires the major investment in capital facilities and operation costs. This is due to the large volume of product to be handled at reduced rates of application in order to obtain well-treated effluent.

Southside Plant

At the Southside plant, secondary treatment begins with the first-stage trickling filters. The volumetric loading on these filters is controlled by recirculation of the filter effluent through the primary clarifiers. The desired average flow through the primary clarifiers and filters is 40 m.g.d., with three clarifiers and three primary filters in service. As the raw sewage flow varies from minimum to maximum the recirculation is controlled by a submerged variable orifice to make up the difference between the raw sewage flow and the 40 m.g.d. plant flow desired. The actual average values for the past year were 23.3 m.g.d. of raw sewage and 13.3 m.g.d. of recirculation, making a total of 36.6 m.g.d. total average flow through the primary clarifiers and filters.

Figure 1 shows the B.O.D. and sus-

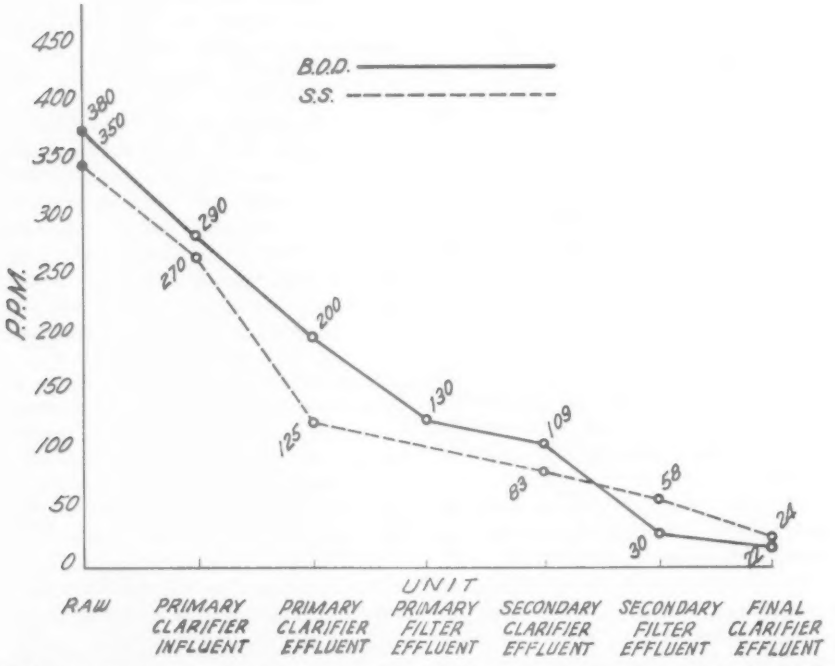


FIGURE 1.—Average B.O.D. and suspended solids for each treatment unit, Southside sewage treatment plant, Oklahoma City, Okla.

pended solids data for each successive unit of treatment as the sewage proceeds through the plant. At the average flow rate of 36.6 m.g.d., the detention time in the primary clarifiers is 1.92 hr. The volumetric loading on the primary filters was 24.4 m.g.a.d., and at a mixed sewage B.O.D. load of 290 p.p.m.*, the organic load was 6,780 lb. of B.O.D. per acre-ft. per day. Removal was 45.5 per cent through the filters and secondary clarifiers. Even though the organic loading on three filters is quite high, this method of operation is used to reduce the detention time in the primary clarifiers for odor control and to more efficiently use the 20 m.g.d. sewage pumps.

The second-stage trickling filters are operated continuously by recirculation of final plant effluent during periods of low raw sewage flow. The secondary recirculation pumps are turned off when the raw sewage flow reaches the 15 m.g.d. rate or higher, which is the minimum capacity of the eight rotary distributors.

The total average recirculation to the secondary filters for 1956 was 5 m.g.d., making the total average daily volumetric load 28.3 m.g.d. (or 5.66 m.g.a.d.). The organic loading was 739 lb. of B.O.D. per acre-foot per day. The removal of B.O.D. through the secondary filters was 76.6 per cent.

This type plant has been successful in handling a relatively strong and variable waste as evidenced by the fact that the final effluent for 1956 averaged 22 p.p.m. B.O.D., 24 p.p.m. suspended solids, and 4.8 p.p.m. dissolved oxygen.

The nitrogen data (Table III) also is an indication of the degree of treatment. The primary filters produced a significant quantity of nitrate nitrogen, which averaged 2.27 p.p.m. during 1956. This is not always accomplished with filters of shallow depth. The final plant effluent had an average nitrate-nitrogen concentration of 5.97 p.p.m. This degree of treatment is sufficient for the North Canadian River since stream data indicates continued reduction in B.O.D. and increased dissolved oxygen content at progressive downstream stations.

* Raw B.O.D. is 380 p.p.m.; mixed B.O.D. (flow and recirculation) is 290 p.p.m.

TABLE III.—Southside Plant Nitrogen Data

Item	Nitrogen (p.p.m.) as			
	Organic	Ammonia	Nitrite	Nitrate
Raw sewage	25.1	26.6	—	—
Primary stage effl.	14.8	32.8	0.06	2.27
Final plant effl.	7.0	20.3	0.37	5.97

Northside Plant

At the Northside plant, secondary treatment begins in the aerated flumes between the primary clarifiers and the mixed liquor tanks and terminates in the final settling tanks.

A brief summary of operation of the secondary treatment units is given in Table IV.

In analyzing the data in Table IV,

TABLE IV.—Northside Plant Secondary Treatment Data

Item	Average
Returned sludge (%)	31.2
Air (cu. ft./gal.):	
Raw sewage	1.75
Mixed liquor	1.21
B. O. D. (p.p.m.):	
Primary clarifier effl.	171
Final effl.	19
Aeration tanks:	
Detention (hr.)	7.2
Dissolved oxygen (p.p.m.)	1.4
Suspended solids (p.p.m.)	2,360
Settleable solids (%)*	43
Sludge volume index	182
Nitrogen (p.p.m.):	
Organic, raw	15.9
Organic, final effl.	8.6
Ammonia, raw	27.7
Ammonia, final effl.	29.9
Nitrite, final effl.	0.40
Nitrate, final effl.	1.5

* After 30 min.

it must be kept in mind that these are average values only and are subject to wide variations.

The dissolved oxygen in the mixed liquor tanks would be low for some plants. However, the peak daily loads have been absorbed successfully by increasing both the aeration time, quantity of air, and the per cent of returned sludge during this period.

The 1.5 p.p.m. of nitrate in the final effluent has proven satisfactory in the receiving stream. Algae or plankton have not developed beyond normal expectations. The stream condition is good, as evidenced by an increase in D.O. saturation and a decrease in B.O.D. concentration at downstream stations.

Conclusion

Planning for the future, including the metropolitan area, is recognized and steps are underway to find solutions to present and future problems.

The corporate area is adequately served at this time by sewage treatment facilities. The new Southside plant was placed in service in 1950 and was designed to treat a heavy industrial load with two-stage trickling filters and it has been successful. The new Northside plant was placed in service in 1952 and was designed to treat domestic sewage by use of the activated sludge process, and this also has proven satisfactory.

Acknowledgments

The assistance and helpful comments of M. B. Cunningham, Superintendent, Water Department; Frank S. Taylor, Assistant Superintendent, Water Department; and J. B. Douglas and C. A. Zoeller are greatly appreciated.

INTERESTING EXTRACTS FROM OPERATION REPORTS

"A man usually can do more than he thinks he can,
but he usually does less than he thinks he does."—*Anon.*

Attention operators! It will be appreciated if copies of the annual reports of both large and small sewage and industrial waste treatment plants are sent to the Federation office for abstracting in this section of the Journal. Please direct annual reports to: The Operator's Corner, Federation of Sewage and Industrial Wastes Associations, 4435 Wisconsin Ave., N.W., Washington 16, D. C.

Annual Report of the Boise, Idaho, Sewage Treatment Plant for the Year 1955 *

General

The Boise, Idaho, activated sludge plant continued to enjoy good public relations with the citizens of Boise. Plant grounds were well maintained and a playground was kept attractive for neighborhood use.

Connected population continued to increase gradually and the daily sewage flow varied from 3 to 14 m.g.d., averaging 6.2 m.g.d. The average daily flow for the period 1951–54 was 7.0 m.g.d. The decrease in flow may be attributed to the sewer replacement program which seeks to replace lines with a high rate of infiltration. Precipitation for the year was also less than previously.

Improvements during the year included:

* For last previous report see THIS JOURNAL, **27**, 3, 347 (Mar., 1955).

1. Construction of an aluminum portable shed to house sewer maintenance equipment.
2. Installation of air-lift pumps for sludge transfer.
3. Installation of valves to control the exhaust from the blower engines.
4. Construction of a block building to protect the lawn irrigation electric pump.
5. Construction of a concrete splash-back around the manhole into which septic tank cleanings are discharged from tank trucks.

Operation

The treatment facilities continued to produce a satisfactory effluent with 93 per cent removal of suspended solids and 92 per cent removal of B.O.D. The sewage received at the treatment plant is relatively weak, whereas the flow capacity is frequently overtaxed. The B.O.D. loading seldom exceeds one-third of the B.O.D. reducing capacity of the plant. This has made satisfactory operation quite difficult at times.

In July the use of the sludge volume index as a process indicator was replaced with an "Oxidation Index." This index is based on an optimum value of 100 per cent, which represents sludge condition at its peak effectiveness.

A licensed method of measure and control, known as the "Oxidized Sludge Process" was acquired. Centrifugal tests are made every 6 hr. on the mixed liquor and returned sludge. These tests serve as a guide in the proper control of the returned sludge rate. Settling tests, made two or three times each day, show the condition of the secondary cycle as compared to an optimum value that represents the condition of the sludge when it is at its peak for producing the best quality effluent. With this method of control the operators have been able to allay any bulking of the activated sludge. As a result operation has been much more stable.

Operation costs increased by $2,183.68 over 1954. This rise is attributed mainly to increased maintenance costs. The total cost of the plant construction in 1949 was $1,116,000 and the operating cost for 1955 was $57,808.84, exclusive of capital improvements. This agrees closely with a "rule-of-thumb" normal operating cost of 5 per cent for an activated sludge plant such as the Boise plant.

Equipment

Routine operation and maintenance kept the equipment in first-class condition. Considerable painting of buildings and equipment was done.

One comminutor drum, damaged by a large timber, was replaced. The chemically treated wood chips were replaced in the gas engine fuel scrubber. Largest maintenance project was the complete overhauling of the pump and blower engines. This work entailed the grinding of valves and the replacing of pistons. The raw sewage pumps and raw sludge pumps were inspected and worn parts replaced.

Two aerators and one primary and secondary clarifier were drained and the equipment inspected. Piping was installed to all moving parts of the secondary clarifier rake arms to facilitate lubrication of submerged parts without draining.

Sewer Maintenance

Sewer maintenance has settled into a normal operation. During the year, 13 per cent fewer service calls were made to clear stoppages in public sewer lines. When stoppages occur in private lines the residents are notified that it is in a private sewer.

During the year plant personnel were active in assisting the citizens of the "Bench" area in promoting sanitary sewers. Statistical data were gathered by residents and a survey was made by the local office of the U. S. Geological Survey.

The need for sewers in this unin-

corporated area is quite evident. During the summer months the water table is less than 5 ft. below the ground surface. Added to this is the surcharge from septic tanks serving the 1,400 houses in the area. Creation of a sanitary district appears to be one solution. However, progress has been stymied by the lack of money to defray legal and other immediate expenditures incident to the formation of the district.

The 1955 operating data are summarized in Table I:

TABLE I.—Summary of 1955 Operating Data at the Boise, Idaho, Sewage Treatment Plant

Item	Average
Connected population, est.	28,070
Population equivalent, est.	36,270
Sewage flow (m.g.d.)	6.2
Suspended solids:	
Plant influent (p.p.m.)	147
Clarifier effluent (p.p.m.)	70
Final effluent (p.p.m.)	9
Removal (%)	93
B.O.D., 5-day:	
Plant influent (p.p.m.)	114
Clarifier effluent (p.p.m.)	86
Final effluent (p.p.m.)	9
Reduction (%)	92
Aeration tank data:	
Aer. period (hr.)	6.1
Air supplied (cu. ft./gal.)	0.87
Returned sludge (%)	36
Mix. liq. susp. sol. (p.p.m.)	908
Sludge index *	376
Oxidation index †	159
D.O. (p.p.m.)	2.6
Sludge susp. sol. (p.p.m.)	3,438
D.O., final effluent (p.p.m.)	5.6
Chlorination data:	
Applied (p.p.m.)	1.45
Sludge digestion, data:	
Sludge to dig. (gal./day)	42,422
Temp. (° F.)	91.5
pH	6.9
Sludge gas data:	
Used, est. (cu. ft./day)	21.54
Cu. ft./lb. dry solids	9.3
Operating cost ($):	
Treatment, operation	57,808.84
Improvements and equipment	2,551.54
Collection system maintenance	10,321.57
Sewer improvements	22,772.64
Revenue ‡	605.50
Total	82,527.52
Per m.g.d.	25.67
Per capita	1.59

* Based on seven months of operation (Jan.–July).
† Based on five months of operation (Aug.–Dec.).
‡ Septic tank cleaner licenses and sludge sales.

SEWER MAINTENANCE IN LONG BEACH, CALIFORNIA *

By Richard Pomeroy

Consulting Engineer, Pomeroy and Associates, Pasadena, Calif.

Editor's Note.—This paper was presented as part of the first scheduled sewer maintenance forum at a Federation Annual Meeting. The forum was well received by those in attendance. Other forum papers are scheduled for future issues of the Journal.

City officials have various understandings of what constitutes sewer maintenance. In some cities, the operation of a maintenance crew may be likened to the fire fighters at a fire station, waiting for some trouble to arise and then rushing into action to take care of the immediate situation. In other cities, some preventive main-

* Presented at the 29th Annual Meeting, Federation of Sewage and Industrial Wastes Assns.; Los Angeles, Calif.; Oct. 8–11, 1956.

tenance is carried out in the form of sewer flushing; a practice which does a small amount of good for a block of two from the upper end of the sewer, but has a negligible effect farther downstream.

There are other cities where a comprehensive program of preventive maintenance is in effect. Sewers are cleaned routinely and trouble is detected before the emergency stage is reached. There are good reasons for believing that the policy of preventive maintenance is, in the long run, the one which has the lowest over-all cost to the community.

Preventive Maintenance

Stoppages Reduced

An effective preventive maintenance program can reduce the number of sewer stoppages and effect a substantial saving in repair costs. The old maxim "a stitch in time saves nine" is nowhere more appropriate than in sewer maintenance.

The saving made by the prevention of stoppages is a substantial item toward offsetting the cost of a maintenance program. Furthermore, the expense borne by the city is not all of the cost that should be attributed to stoppages. Private property suffers damage which may sometimes be far greater than the cost to the city administration for removing the stoppage.

In the City of Long Beach, Calif., before a preventive maintenance program was started, sewer stoppages averaged 350 per year. With the greater mileage of sewers now in service (620 miles) there would probably be about 500 stoppages. The preventive sewer maintenance program has effected a reduction in the number of stoppages to 26 in 1955, or about 4 per 100 miles per year. This is a reduction of more than 90 per cent.

Damage Detected Early

A regular system of sewer inspection and maintenance aids in the detection of broken sewers before street cave-ins can occur. A cave-in is a public hazard and a source of inconvenience until repaired. Moreover, the repair is likely to be more expensive than if it had been made before the point of failure was reached.

When the City of Long Beach, Calif., first completely cleaned its sewers, many pipes were found to be crushed or damaged so that the cleaning tools would not go through. These places were excavated and repaired. Each year a number of sections of sewer are found where a broken pipe, bad joint, poor building sewer connection, or other cause has permitted soil to wash into the line, thereby producing a cavity around the pipe, which will eventually result in a cave-in if not detected and repaired in the preventive maintenance operations.

Capacity Maintained

Periodic cleaning prevents impairment of sewer capacities by keeping the lines relatively free from deposits. A sewer with a considerable accumulation of grit, grease, egg shells, and sludge in the bottom may easily have its capacity reduced by one-half. Most sewers must be cleaned sooner or later because of reduced capacity or other reasons.

Garbage Grinders

The fouling of sewers is increasing as a result of the greater use of garbage grinders. About one-third of the homes in Long Beach, Calif., are equipped with garbage grinders. As a result, many lines require annual cleaning whereas they would have been cleaned at intervals of 2 or 3 years. The cleanings frequently are 90 per cent egg shells. The effect of garbage grinders can be taken as a routine matter when a city has a regular sewer cleaning program. Cities which do not have an effective maintenance program will find it increasingly difficult

to cope with this problem of sewer fouling.

Because of the increase in sewer maintenance costs, the question naturally arises as to whether garbage grinders are an economical method of garbage disposal. A careful cost study was made by the City of Long Beach, Calif., to compare garbage pick-up with sewer cleaning. It was found that in the areas served entirely with garbage grinders, the entire cost of a thorough sewer cleaning program, including at least annual cleaning, is between one-quarter and one-third of the cost of garbage collection. The effects of garbage on sewage treatment and disposal costs should be considered in an over-all study of the problem, but these will be considerably less than the effect on the cost of sewer cleaning.

FIGURE 1.—Sewer ball just entering downstream manhole.

Odor Elimination

Sulfide generation is reduced and often eliminated by periodic cleaning of the sewer lines. Deposits in the bottom of a sewer reduce the velocity of sewage flow and provide more surface area for sulfide-producing slimes. There are many instances where a good cleaning program is all that is needed to solve a sulfide problem, although this is not always the case.

In order to assure an effective reduction in odors, it is necessary for a sewer to be cleaned with a ball or other hydraulic device. Mechanical devices on the ends of rods may be necessary for the purpose of opening up a sewer that is badly fouled, but a ball must also be used if thorough scouring and cleaning is desired (Figure 1).

Public Liability

Having an effective preventive maintenance program will reduce the threat of damage suits, which could result from a lack of preventive maintenance. There have been some court decisions in recent years holding cities liable for damages caused by overflowing sewers, on the grounds that a city is negligent if it does not take reasonable steps to prevent such occurrences. Aside from what it may cost the city if it is an unsuccessful defendant in a lawsuit, these court decisions should be considered as a judgment that the city has certain obligations for proper maintenance regardless of whether or not the public works department of the city is so inclined.

Cleaning Costs

Cleaning and maintenance costs are of particular interest. When an old sewer system in an average state of repair is cleaned for the first time the cost may range from $400 to $800 per mile of sewer. Under particularly adverse conditions the cost may be even higher. With a regular cleaning program the cost will be much lower.

At current wage scales the Long Beach, Calif., cost averages $96 per mile of sewer cleaned. This is probably an extreme lower limit for thorough cleaning, attainable only in a fairly large city with a high degree of efficiency.

A number of small cities in Southern California contract with sewer maintenance companies, and the Sewer Maintenance Department of Los Angeles County also does contract work for cities. Contract prices for the scattered work of small cities, with the elements of cost that must be considered, are necessarily much higher than the costs cited for Long Beach. For annual or biennial cleaning after the first cleaning, the contract price will usually range from $200 to $400 per mile.

The foregoing costs are for cleaning alone per mile of sewer cleaned. Long Beach cleans about 75 per cent of the sewers each year. In addition to the sewer cleaning, the maintenance program includes repairs, removal of stoppages, fixing noisy manhole covers (Figure 2), roach control, sulfide control, and all other activities necessary to keep the system in first class working order.

It is estimated that the total maintenance cost on the sanitary sewers at Long Beach, Calif., is about $130 per mile per year, with about one-half of this amount attributable to routine cleaning. This again is probably an extreme lower limit of cost for the type of job that is done. At most, the costs should not be large in comparison with the value of the sewer system. The annual maintenance cost will generally be less than 1 per cent of the current construction cost.

FIGURE 2.—Rubber gasket quiets a noisy manhole cover.

When a city starts a program of preventive maintenance, the initial expenditure often appears to be considerable. It is sometimes advantageous, therefore, for the city to spread the initial cleaning over a three-year period.

Records

An efficient maintenance program requires a good record system. A sketch system has been developed whereby the records are kept in a usable form with a minimum of effort. Each cleaning crew makes a schematic sketch of the sewer as it works along, noting all information which will be of use when the sewer is again cleaned. Notes are made concerning any places where roots are found or where there are excessive accumulations of sludge or grease; locations of basements and their elevations if they are connected to the sewer; evidences of damage or faulty structures; surface information such as "bad dog," "public comfort station"; etc. When the sketch is brought back to the city yard, the information is transferred to a sub-area map which covers approximately a square mile. It takes about 10 min. to copy the information from the report of one crew. A decision is made then as to when the sewer will be cleaned again. Each time a crew starts its day's work, the map of the particular line or lines to be cleaned is checked for the information previously reported.

Equipment

Two principal types of equipment are used for cleaning, sewer balls and flexible rods with attachments. The

FIGURE 3.—The sewer ball, although inflated, must be soft.

heavy rubber sewer ball with spiraled ribs (Figure 3) is inflated until it is slightly smaller than the pipe diameter. In operation, it is restrained by a rope so that a suitable head of water can build up behind it. This head may be created by sewage flow in the large lines, or by water from fire hydrants in the small lines. Where there are basements or other connections at a low elevation, it is necessary to clean with a water head only a few inches above the top of the pipe. More rapid progress can be made where a head of 1 to 4 ft. can be used.

The spiral ribs on the ball impart a spiral motion to the water on the downstream side. This rotary motion of the water has a scouring effect farther downstream from the ball than do the straight jets of water around the ball.

When one of these balls was observed in a plastic pipe it was of interest to find that the ball rotated slowly, sometimes in a direction opposite to what would be expected from the direction of rib spirals. Closer observation revealed that the ball had a rotary oscillation in a direction opposite to the rib spirals. The ball tends to roll around the inside of the pipe, so that when this effect is dominant the ball will rotate in the same direction as the ribs, or "against the water."

Balls without ribs are still used to a considerable extent in Southern California, and under most conditions are effective. For large sewers, use is often made of a "hoe" which is a cylindrical partial dam with a handle extending upstream. Cleaning with a hoe is done without surcharging the sewer. The county sanitation districts of Orange and Los Angeles counties have large hoes equipped with wheels to hold the dam off the bottom of the sewer so that the water shoots under the dam with an effective scouring action.

Cones are used in some cities to direct a jet of water down the center of the pipe. Usually this method does not work as well as a device which jets the water around itself next to the wall of the pipe, especially if the pipe is rather badly fouled.

Cleaning Procedure

The usual cleaning procedure in Southern California cities is to start by putting a ball into the sewer, unless the sewer is known to be badly fouled. If the ball, restrained from too rapid advance by use of a rope, makes its way to the next manhole, complete cleaning of that section has been accomplished. Grease and considerable amounts of debris are removed, and roots up to the diameter of a pencil are usually broken off. A man in the downstream manhole shovels heavy debris into a bucket for removal from the sewer.

If the ball cannot get through, it is pulled back and a rod with an auger is used. If use of the ball reveals that the sewer is badly fouled with debris, or if it is known in advance that this is the case, a bucket machine is used. In either case, a ball is used to finish the job. If no tool can get through,

the sewer is dug up at the trouble point. Rarely does a ball fail to get through on the first try if a regular maintenance program has been in effect.

Plain flushing is not generally used. Flushing does only a small amount of good near the upper ends of laterals, and it is quite ineffectual a few hundred feet downstream.

Sewer cleaning requires skills not readily acquired from manuals or printed instructions. A city that plans to inaugurate a program of preventive maintenance should secure the services of someone who has had experience with the best sewer cleaning practices, to train personnel for several months. Through work with an experienced maintenance man, local personnel will acquire the knack of the cleaning operations and learn how to deal with the varied situations that arise. Many cities hesitate to undertake a program of sewer cleaning because they have had unfortunate experiences in emergency situations and have not known what to do.

Acknowledgments

The author appreciates the assistance of Sydney Preen, Superintendent of Sewers, and Charles G. Skidmore, Foreman, Sewer Maintenance, Long Beach, Calif., for information and photographs used.

TIPS AND QUIPS

Knowing's Not Enough!

Knowing how to prevent accidents is not enough. Sometimes it seems we do things even against our better judgment. These states of mind might be called "imps"—imps which block out safety awareness.

We are all acquainted from personal experience with the following four imps:

Impatience
Impulsiveness
Impunity
Improvising

Right now, think about the instances when you have been confronted by one of these imps—at work, out driving, or around home. They are especially active when you are tired or out-of-sorts.

Remember—knowing's not enough, you must act safely.

Synthetic Starch

Laboratory personnel who dislike the mess and inconvenience of preparing starch for use in D.O. titrations will welcome Thyodene to the field of iodimetry. This organic powder looks like the answer. Successfully field-tested in European labs for several years, the dry, white, stable substance has two unique advantages: it is (a) ready-to-use, requiring no preparation of any kind; and (b) it cannot deteriorate or ferment, being unaffected by bacteria or molds.

The blue endpoint is reported fully as sharp and sensitive as with starch. Fisher Scientific, Washington, D. C., suppliers of Thyodene, state that the powder simply can be added while titrating.

Filter Fly Control

Test work reported by the California Spray-Chemical Corp. indicates that weekly spray applications of a mixture of two quarts Isotox Spray No. 200 (containing lindane) and one pint of Vapotone XX Spray per 100 gal. of water will keep *Psychodidae*, the sewage filter fly under control. This quantity makes sufficient spray to control flies around the average .3 m.g.d. filter plant. Dosage should be adjusted

according to plant size. For best results treatment should commence in the spring. Remember to handle the insecticides with caution.

Daphnia

A new source of revenue for sewage treatment plants has been reported from California. Ed. Sampson, chief operator at Oceanside, Calif., harvested a crop of daphnia, better known as water fleas, from his oxidation ponds and sold the insects for fish food.

The resourceful operator always has his eyes open and keeps his mind active.

Compact First Aid Station

A first aid wall-mounting cabinet small enough (20 in. by 24 in. by 11 in.) to mount close to hazardous areas, yet large enough to hold all necessary first aid items, is available. The cabinet doors are fitted with a positive-action catch that cannot open as a result of nearby vibration.

Information may be obtained from the General Scientific Equipment Co., P. O. Box 3038, Philadelphia, Pa.

Accidental Death from Electric Current *

About 95 per cent of the fatal accidents caused by electric current in the United States occur among males, reflecting largely the effect of occupational hazards. Of the 2,044 persons who lost their lives from electric shock in the two years 1951 and 1952, no less than 1,738 were males in the age range from 15 to 64. One-fifth of all males killed by electric current during this period sustained their injuries on industrial and utility premises. Nearly the same proportion of men were electrocuted on streets and highways, particularly utility company personnel and crane operators.

Encouraging, however, is the fact that in spite of the tremendous increase in residential and industrial consumption of electricity the present death rate is 7 per million population whereas a quarter century ago the corresponding death rate was 9 per million.

* Metropolitan Life Insurance Co., *Statistical Bulletin*, **36**, 5 (May, 1955).

Nickel Savings

Nickel savings that add up are now possible with ion exchangers that permit the nickel and the rinse water from nickel plating operations to be recovered for re-use, and eliminate the need for expensive detoxification of the rinse solution. A two-fed deionization system removes cations and anions producing water that can be used rather than a waste requiring special treatment.

A split-elution technique is sometimes employed in the regeneration process, permitting the reclaiming and re-use of higher concentrations of nickel for the plating baths. In addition to saving scarce nickel, this in-plant recovery of an industrial waste product saves considerably on sewer service and water supply charges.

Fore!

Golfing fans in El Cajon Valley, Calif., can thank the presence of a modern sewage treatment plant for making a new golf course possible.

El Cajon has made arrangements to deliver treatment plant effluent that will be used to irrigate the greens and fairways. Without this beneficial use of sewage effluent the course could not be irrigated economically.

Not only does this sewage treatment plant protect the public health and recreational facilities but it makes possible healthy recreational activities.

Editorial

THE REVISED CONSTITUTION AND BYLAWS

At its meeting of October 7, 1956 the Board of Control adopted significant revisions to the Constitution and Bylaws of the Federation. While most of the Committee's recommendations, presented by Past President George J. Schroepfer, Chairman of the Committee, were approved without objection, several resulted in a lively discussion. These documents start on page 369 of this issue. Your careful reading is suggested and your comment is invited.

Major changes were made in the membership of the Board of Control itself. Member Associations with a sustained membership of over 500 may now name two Directors to the Board instead of one. This will give the large associations a degree of proportional representation on the Board. At the present time, the Central States, New York, California and Pennsylvania Associations are entitled to this new privilege. As other Member Associations exceed and sustain a membership over 500, they will earn the same right.

The second change affecting Board membership was the withdrawal of Director status for chairmen of the Publications and Program, Organization, Sewage and Industrial Wastes Practice, Research, Finance, and Standard Methods Committees. These chairmen will act in an advisory capacity to the Board by attending Board Meetings and participating in discussion. They no longer will have the privilege of making motions or voting. Further, the previously indefinite tenure of these chairmen is now limited to five years. As a result of these changes, the current maximum Board of Control membership has been reduced from 54 to 52, with the Treasurer the only member with an unlimited term.

To the group of committee chairmen advisory to the Board was added the Industrial Wastes Committee chairman. This recognition of the importance of this Committee is certain to be popular. Other revisions include the establishment of the Nominating Committee and a General Policy Committee in the Bylaws.

While the Board adopted essentially all the changes suggested by the Committee, it asked the Committee to reconsider (a) the time limitation of the Advisory Committee Chairmanships, and (b) the limitation of one term on service of Member Association Directors on the Board of Control. The latter item has caused hardship on some of the small Member Associations.

The revised Constitution limits the assignment of proxies for Directors to members of the organization represented. The Annual Meeting of the Federation is no longer limited to the month of October, although it is expected to continue this pattern. A change long awaited was the renaming of the former "Publications Committee" to the "Publications and Program Committee," to recognize its role in the preparation of the Annual Meeting Program.

All those affiliated with the Federation should realize that these primary documents have been given a thorough review and that they are now in a form accepted by the Board of Control. Experience with the revised Constitution and Bylaws will test the wisdom of these changes as well as point the way for other modifications. Such is the course of an alert and democratic organization, and to keep it so should be the primary aim of all.

R. E. F.

Reviews and Abstracts*

Tide and Santomerse in the Sewage Works. By R. D. Raybould, and L. H. Thompson. *Surveyor,* **115**, 41 (1956).

The effects of synthetic anionic detergents on sedimentation, sludge digestion, and sewage purification by trickling filters and activated sludge were examined in plant-scale and laboratory experiments.

It was concluded that primary sedimentation was unaffected by the presence of detergents, and that 33 per cent of the detergent present in the raw sewage was removed by primary sedimentation.

Trickling filters removed from 39 to 60 per cent of the detergent present in the filter influent, with slow progressive removal occurring throughout the depth of the filters. There was little effect on purification during the summer, when the sewage contained a minimum amount of gas liquor. However, during the winter, when the gas liquor flow was higher and the loading on the treatment plants therefore heavier, the addition of detergents produced effluents of lowered quality.

Activated sludge gave analogous results. When the plants were moderately loaded purification was little affected, and nitrification was actually improved by the addition of detergents. However, at times of maximum load the detergents produced decreases in both purification and nitrification. The sludge tended to bulk in the summer and winter when detergents were added, except in the case of one product containing silicates as additives. It was concluded that the silicates prevented the bulking by weighing the sludge. This effect, however, might not be observed in plant practice since the silicates might be removed in primary sedimentation.

The addition of 600 p.p.m. of active detergent to digesting sludge mixtures initially inhibited gas production. With detergents containing no additives, gas production recovered in about one month, and leveled off at 85 to 90 per cent of the rate observed in the controls. A detergent containing additives caused a much longer lag in gas production, indicating that the additives may be more troublesome than the detergents themselves. Secondary alkyl sulfates were completely destroyed, but only 15 to 20 per cent of the alkyl aryl sulfonates were destroyed in the digestion process.

M. C. Rand

Recent Developments in the Control of Stream Pollution. By B. A. Southgate and A. L. H. Gameson. *Surveyor,* **115**, 349 (1956).

The management of rivers in England is reviewed. In order to control pollution of river systems, River Boards have been formed, 34 of which now perform the function exercised previously by more than 1,600 authorities. Standards of quality of effluents which may be discharged are not as yet enforceable by law, but are controlled by these River Boards through the use of bylaws of the Rivers Act of 1951.

Standards are restricted to such determinations as B.O.D., flow and ultimate demand. The physical factors of flow, depth, mud deposits and synthetic detergents are considered, and use of rivers for sanitary purposes is specified in detail, as well as the capacity for selfpurification and the deterrent effects of trade wastes.

Surveys of three rivers, the Tees (1929–33), the Mersey (1933–37) and the Thames (1949–to date), are mentioned. Treatment of trade wastes is a major problem, particularly coke wastes. Pilot-plant studies indicate that anaerobic digestion offers promise for coke waste treatment.

F. W. Mohlman

* Please send to Federation headquarters all periodicals, bulletins, special reports, etc., which might be suitable for abstracting in This Journal. Publications of public health departments, stream pollution control agencies, research organizations, and educational institutions are particularly desired. Address such material: Federation of Sewage and Industrial Wastes Assns., 4435 Wisconsin Ave., N.W., Washington 16, D. C.

Federation of Sewage and Industrial Wastes Associations

Annual Year Book
and
Supplemental Directory
1957

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HONORS AND AWARDS

Honorary Members

The qualifications for Honorary membership in the Federation are set forth in Article II, Section 4 of the Bylaws. Honorary Members are elected upon recommendation of a committee comprising the President and four latest Past Presidents, the senior Past President as chairman, in accordance with a policy adopted by the Board of Control on October 23, 1943. Honorary Members elected to date are as follows:

*Charles Alvin Emerson.....1941
*Arthur S. Bedell.....1942
*Julius W. Bugbee.....1942
*Langdon Pearse.....1942
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Albert Edward Berry.....1954
William Thomas Lockett.....1954
Gordon Maskew Fair.....1955
William H. Wisely.....1956

The Harrison Prescott Eddy Medal

The Harrison Prescott Eddy Medal is awarded annually to a member of any Member Association of the Federation for outstanding research contributing in important degree to the existing knowledge of the fundamental principles or processes of sewage treatment, as comprehensively described and published during any stated year in SEWAGE AND INDUSTRIAL WASTES. The award commemorates Harrison Prescott Eddy, a famous engineer and a pioneer in the art of sewage treatment.

* Deceased.

Past recipients of the award are:

Harry Willard Gehm.....1943
John Raymond Snell.....1944
Lloyd R. Setter.....1945
H. Heukelekian.....1946
Richard Pomeroy and
Fred D. Bowlus.....1947
F. W. Kittrell and
O. W. Kochtitzky, Jr.....1948
John W. Hood.....1949
Daniel A. Okun.....1950
Peter S. S. Dawson and
Samuel H. Jenkins..... 1951
George S. Benton, John C. Geyer,
Wen-Hsiung Li, and Knut K.
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Donald M. Pierce.....1953
William J. Oswald, Harold B.
Gotaas, Harvey F. Ludwig, and
Victoria Lynch.....1954
William J. Katz, William L. Lea,
Gerard A. Rohlich.....1955
G. J. Schroepfer, W. J. Fullen,
A. S. Johnson, N. R. Ziemke,
J. J. Anderson.....1956

The George Bradley Gascoigne Medal

The George Bradley Gascoigne Medal is awarded annually to a member of any Member Association of the Federation for outstanding contribution to the art of sewage treatment works operation through the successful solution of important and complicated operational problems, as comprehensively described and published during any stated year in SEWAGE AND INDUSTRIAL WASTES. This award is in memory of George Bradley Gascoigne, a prominent consultant from 1922 to 1940, who demonstrated an unusual interest in matters of sewage works operation.

Past recipients of this award are:

Kerwin L. Mick.....1943
James T. Lynch and Uhl T. Mann...1944
John D. McDonald.....1945
LeRoy Winfield Van Kleeck.....1946
Leon S. Kraus.....1947
David P. Baekmeyer.....1948
Wilbur N. Torpey.....1949
Clarence E. Keefer.....1950
Leonard S. Hillis.....1951
Walter Asa Sperry.....1952
W. N. Wells and Clarence H. Sherer 1953
Robert Ditmar Bargman.....1954
Abraham H. Chasick.....1955
Henry R. King.....1956

The Charles Alvin Emerson Medal

The Charles Alvin Emerson Medal is awarded annually to a member of any Member Association of the Federation "for outstanding service in the sewerage and sewage treatment works field, as related particularly to the problems and activities of the Federation of Sewage and Industrial Wastes Associations in such terms as the stimulation of membership, improving standards of operational accomplishments, fostering fundamental research, etc." This award honors Charles Alvin Emerson, who served as President of the Federation from 1928 to 1941 and holds the distinction of being its first Honorary Member.

Past recipients are:

Floyd William Mohlman.....1943
Willem Rudolfs.....1944
Harold Warner Streeter.....1945
F. Wellington Gilcreas.....1946
*Langdon Pearse.....1947
LeRoy Winfield Van Kleeck.....1948
William J. Orchard.....1949
Morris M. Cohn.....1950
Howard Eugene Moses.....1951
*Frank Woodbury Jones.....1952
William D. Hatfield.....1953
*Charles C. Ruchhoft.....1954
Merle Starr Nichols.....1955
E. Sherman Chase.....1956

* Deceased.

The Industrial Wastes Medal

The Industrial Wastes Medal was established in 1949 to be awarded annually in the form of a plaque for the most outstanding contribution by an industrial employee on any aspect of industrial wastes control, as published in SEWAGE AND INDUSTRIAL WASTES during the year preceding the award.

Past recipients are:

Roy F. Weston, Robert G. Merman and Joseph G. DeMann.....1950
Bruce W. Dickerson.....1951
Robert J. Austin, Roy N. Giles, C. T. Nicholson, and F. W. Sciene-man 1952
Richard H. Coe.....1953
*N. H. Sanborn.....1954
Kenneth S. Watson.....1955
Charles R. Griffin.....1956

The Kenneth Allen Award

From 1943 through 1948, meritorious personal service to Member Associations was recognized by the Kenneth Allen Award. The award was retired in 1948.

Recipients of this award have been:

1943

Harry Thornton Calvert (ISP)
Edward F. Eldridge (Mich.)
John Kurtz Hoskins (Fed.)
Fred Merryfield (Pac. N.W.)
Edward P. Molitor (N.J.)
Robert S. Phillips (N.C.)
Alfred Henry Weiters (Iowa)
William Homer Wisely (Cen. St.)

1944

Albert Edward Berry (Can.)
Van Porter Enloe (Ga.)
Albert Legrand Genter (Md.-Del.)
F. Wellington Gilcreas (N. Eng.)
Charles A. Holmquist (N.Y.)
Dana Ewart Kepner (Rocky Mtn.)
Leon Benedict Reynolds (Calif.)
Wilson Waldo Towne (Dak.)

1945

Howard Eugene Moses (Pa.)
George S. Russell (Mo.)
Dario Travaini (Ariz.)
Frederick Holman Waring (Ohio)
Joe Williamson, Jr. (Fla.)
Murray Alderson Wilson (Kans.)

1946

E. J. M. Berg (Texas)
Frank E. DeMartini (Fed.)
John R. Downes (N.J.)
Thomas J. Doyle (Mich.)
John Henry Garner (ISP)
Harold Benedict Gotaas (N.C.)
William P. Hughes (Pac. N.W.)
Theodore R. Lovell (Iowa)
George W. Martin (Cen. St.)

1947

William T. Knowlton (Calif.)
Floyd W. Pinney (Dak.)
Gilbert R. Frith (Ga.)
Clarence E. Keefer (Md.-Del.)
Stuart E. Coburn (N. Eng.)
Wellington Donaldson (N.Y.)
Henry J. Darcey (Okla.)
Carroll H. Coberly (Rocky Mtn.)
William Storrie (Can.)
William Merriman Cobleigh (Mont.)

1948

George W. Marx (Ariz.)
David Bryon Lee (Fla.)
William Q. Kehr (Mo.)
F. Dean Stewart (Ohio)
Francis deSales Friel (Pa.)

* Deceased.

The Arthur Sidney Bedell Award

Established in 1948, the Arthur Sidney Bedell Award acknowledges extraordinary personal service to the Member Associations of the Federation. Each Member Association is privileged to name one of its members to receive the award, which may be earned by organizational leadership, administrative service, membership activity, stimulation of technical functions, or similar participation. The frequency of nomination varies from annually to one in three years, depending on membership. The award is named for the second President of the Federation, who exemplified its purpose by his long devotion and contribution to the affairs of the New York State Sewage Works Association (now the New York Sewage and Industrial Wastes Association).

Past recipients follow:

1949

Harry P. Croft (N.J.)
Victor Marcus Ehlers (Texas)
R. Paul Farrell (Ky.-Tenn.)
Carl Edwin Green (Pac. N.W.)
Frederick Leon McDonald (Ark.)
William Thomas Lockett (ISP)
William McKinney Piatt (N.C.)
Walter Asa Sperry (Cen. St.)
Harold Warner Streeter (Fed.)
John L. Strelow (Iowa)

1950

Leland Bradney (Dak.)
John Chester Brigham (N.Y.)
Herbert B. Foote (Mont.)
L. L. Hedgepeth (Va.)
Theodore J. Lafreniere (Can.)
Robert G. McCall (W. Va.)
Edward Alexander Reinke (Calif.)
Frank S. Taylor (Okla.)
LeRoy Winfield Van Kleeck (N. Eng.)
William Hugh Weir (Ga.)
Leonard Oliver Williams, Jr. (Rocky Mtn.)
Abel Wolman (Md.-Del.)

1951

Roy Binder (Kans.)
John Clinton Clark (Ala.)
John Raymund Hoffert (Pa.)
John Robertson Hoy (Fla.)
Arthur H. Niles (Ohio)
Charles Henry Trusler (ISE)
Harold W. Yost (Ariz.)
Francis M. Veatch (Mo.)

1952

Don E. Bloodgood (Cen. St.)
Herman Glenn Baity (N.C.)
Paul Bolton (Iowa)
P. N. Daniels (N.J.)
Francis W. Kittrell (Ky.-Tenn.)
Ray E. Koon (Pac. N.W.)
Winfred S. Mahlie (Texas)
Clarence Theodore Mudgett (Mich.)
Walter F. Freeborn (ISP)
Harrison Hale (Ark.)
George Ashby Rhame (S.C.)

1953

Robert James Auld (P. R.)
Charles G. Caldwell (Rocky Mtn.)
Nathan M. deJarnette (Ga.)
Anthony J. Fischer (N.Y.)
Ralph E. Fuhrman (Md.-Del.)
Quintin B. Graves (Okla.)
John B. Kleven (Dak.)
Douglas L. McLean (Can.)
Walter E. Merrill (N. Eng.)
Fred F. Palmer (Mont.)
Eugene C. Meredith (Va.)
Henry W. Speiden (W. Va.)
Arthur T. Wintersgill (Calif.)

1954

Arthur N. Beck (Ala.)
Merle V. Ellis (Ariz.)
John W. Wakefield (Fla.)
Max Prüss (Germany)
Gilbert T. Cotterell (ISE)
Leland A. Talbot (Kans.)
Charles A. Haskins (Mo.)
Theodore C. Schaetzle (Ohio)
Bernard S. Bush (Pa.)
Arnold Hoerler (Swiss)

1955

C. H. French (Ark.)
Frederick G. Nelson (Calif.)
George J. Schroepfer (Cen. St.)
Carl E. Schwob (Fed.)
Leo Holtkamp (Iowa)
F. T. Hambleton (ISP)
Herman D. Regan (Ky.-Tenn.)
James L. Love (La.)
Thomas J. Powers (Mich.)
William F. Rapp (Nebr.)
Henry Van Der Vliet (N.J.)
R. C. Sweeney (N.Y.)
P. D. Davis (N.C.)
Emil C. Jensen (Pac. N.W.)
T. R. Haseltine (Pa.)
W. T. Linton (S.C.)
Nils Westberg (Sweden)
J. H. Sorrels (Texas)

1956

Arthur G. Pickett (Calif.)
Ray J. Desmarais (Can.)
W. W. Mathews (Cen. St.)
John E. Kiker, Jr. (Fla.)
Bruce M. McDill (Ohio)
Luis Ramos Robles (P.R.)
William J. Bishop (Okla.)
W. McLean Bingley (Md.-Del.)
Charles E. Drummond, Jr. (Ga.)
Rodney Preator (Mont.)
Steven M. Hurley, Jr. (N. Eng.)
Earl Devendorf (N.Y.)
C. H Young (Pa.)
Harry K. Gidley (W. Va.)
Richard Messer (Va.)

The William D. Hatfield Award

The William D. Hatfield Award recognizes outstanding annual sewage works operation reports. Following the 1946 award, the Board of Control authorized identical awards for outstanding annual reports prepared for plants serving (I) less than 10,000 population, (II) populations of 10,000 to 100,000, and (III) populations of more than 100,000.

This award was discontinued for 1955 and revived in 1956 for presentation on a Member Association basis. The frequency of nomination is identical with the Bedell Award and varies from annually to one in three years depending on membership.

Recipients of this award have been:

1946

Walter M. Kunsch

1947

F. E. Peterson (I)
John R. Szymanski (II)
Warren H. Sleeger and George J. Schroepfer (III)

1948

F. E. Peterson (I) *
Thomas T. Hay (II)
Kerwin L. Mick (III)

1949

Russell D. Craun (I)
George W. Martin (II)
Thomas T. Hay (II) *

1950

William L. Edwards (I)
Walter A. Sperry (II)
John R. Szymanski (II) *
John W. Johnson (III)

1951

William L. Edwards (I) *
J. E. Meers (II)
John R. Szymanski (II) *
George H. Craemer (III)
Kerwin L. Mick (III) *

1952–3; no award.

1954

Uhl T. Mann (II)
J. E. Meers (II) *
C. W. Christenson (Indus.)

1955; no award.

1956

Murray B. McKinnie (Calif.)
I. G. Knoebel (Cen. St.)
F. W. Crane (N.Y.)
Arthur D. Caster (Ohio)
Curtis L. Glenn (Okla.)
Robert Bolenius (Pa.)
A. F. Chamblin (Va.)
George F. Craemer (N. Eng.) *
Robert E. Simon (Fla.)

* Previous winner.

Membership Prizes

Prizes for membership activity in its various Member Associations have been awarded by the Federation since 1943. The numerical prize is given to the Member Association having the greatest numerical increase in membership during the year ending September 30 of the award year. The percentage prize is given for the greatest percentage increase in membership during the same period. The following Member Associations have received these prizes:

	Association			*Association*	
Year	*Num.*	*%*	*Year*	*Num.*	*%*
1943	Cen. St.	Fed.	1950	Iowa	La.
1944	Cen. St.	Mo.	1951	Mich.	ISE
1945	Can.	Ariz.	1952	Cen. St.	Fla.
1946	Can.	Okla.	1953	Calif.	P. R.
1947	ISP	Ark.	1954	Pa.	P. R.
1948	Pa.	W. Va.	1955	Mich.	Ga.
1949	Ohio	Ala.	1956	Cen. St.	Ky.-Tenn.

The Quarter Century Operators' Club

The Quarter Century Operators' Club is an informal group comprising Active or Corporate Members of any Member Association who had been engaged in sewage treatment works operation, on a full-time resident basis, twenty-five years prior to the date of their admission into the Club. The Club was created in 1941 under the sponsorship of Frank Woodbury Jones, who served as its first registrar. The present registrar is Henry Van Der Vliet.

Philip Artese
Harry M. Beaumont
Don E. Bloodgood
Floyd G. Browne
Raymond G. Case
E. Sherman Chase
Morris M. Cohn
John W. Collom
Rodney E. Cook
P. N. Daniels
Nicholas De Haas, Sr.
Earl Devendorf
Joel Clifford Dillard
M. S. Fitzsimmons
George E. Flower
Harry M. Freeburn
E. D. Fry
G. L. Fugate
Ralph E. Fuhrman
Arnold H. Goodman
William P. Gyatt
T. K. Haseltine
Wm. C. Hamm
Herbert W. Hansen
George I. Hanson
William D. Hatfield
Harry J. Krum
Roy S. Lanphear
Carl C. Larson
John V. Lewis
George S. Long
Winfield S. Mahlie
C. D. McGuire
Edwin C. McKeeman
C. T. Mudgett
E. L. Nance
I. H. Nevitt
Arthur H. Niles
Andrew Palmer
John R. Palmer
Wm. M. Piatt
Wm. A. Ryan
Theodore C. Schaetzle
Glenn Searls
*Russell S. Smith
Willard R. Smith
H. W. Streeter
John Struss
Myron W. Tatlock
S. L. Tolman
Henry Van Der Vliet
Edwin B. Wagner
Charles E. Wheeler, Jr.

* Decreased since previous listing.

ANNUAL MEETINGS AND CONVENTIONS

No.	*Location*	*Date*	*No.*	*Location*	*Date*
1	Chicago, Ill.†	Oct. 16, 1928	15	Cleveland, Ohio	Oct. 22–24, 1942
2	New York, N. Y.†	Jan. 18, 1929	16	Chicago, Ill.	Oct. 21–23, 1943
3	New York, N. Y.†	Jan. 14, 1930	17	Pittsburgh, Pa.	Oct. 12–14, 1944
4	New York, N. Y.†	Jan. 22, 1931	18	Chicago, Ill.†	Oct. 17–18, 1945
5	New York, N. Y.†	Jan. 22, 1932	19	Toronto, Ont., Can.	Oct. 7–9, 1946
6	New York, N. Y.†	Jan. 19, 1933	20	San Francisco, Calif.‡	Jul. 21–24, 1947
7	New York, N. Y.†	Jan. 18, 1934		Philadelphia, Pa.†	Oct. 10, 1947
8	New York, N. Y.†	Jan. 18, 1935	21	Detroit, Mich.	Oct. 18–21, 1948
9	New York, N. Y.†	Jan. 16, 1936	22	Boston, Mass.	Oct. 17–20, 1949
10	New York, N. Y.†	Jan. 22, 1937	23	Washington, D. C.	Oct. 9–12, 1950
11	New York, N. Y.†	Jan. 21, 1938	24	St. Paul, Minn.	Oct. 8–11, 1951
12	New York, N. Y.†	Jan. 20, 1939	25	New York, N. Y.	Oct. 6–9, 1952
13	New York, N. Y.†	Jan. 18, 1940	26	Miami, Fla.	Oct. 13–16, 1953
	Chicago, Ill.‡	Oct. 3–5, 1940	27	Cincinnati, Ohio	Oct. 11–14, 1954
14	New York, N. Y.†	Jan. 15, 1941	28	Atlantic City, N. J.	Oct. 10–13, 1955
	New York, N. Y.‡	Oct. 9–11, 1941	29	Los Angeles, Calif.	Oct. 8–11, 1956

DIRECTORY OF COMMITTEES

1956–57

CONSTITUTIONAL COMMITTEES

(*See Article VI of Bylaws*)

Executive Committee of the Board of Control

Emil C. Jensen, *Chairman*

Kenneth S. Watson, *Vice-Chairman*

C. H. Connell
John Carollo
G. W. Martin
T. T. Quigley
W. S. Wise

Publications and Program Committee

The Publications and Program Committee arranges the technical programs for the annual conventions of the Federation and has general supervision of all publications of the Federation.

George E. Symons, *Chairman*

Paul Haney, *Vice-Chairman*

V. Bacon
H. H. Black
R. Eliassen
A. J. Fischer
R. E. Fuhrman
F. W. Gilcreas
L. L. Hedgepeth
R. W. Hess
D. B. Lee
F. W. Mohlman
L. F. Oeming

† Annual business meeting of Board of Control only.
‡ Convention of membership-at-large only.

Organization Committee

The Organization Committee examines and reports to the Board on applications for membership in the Federation and endeavors to encourage the formation of new regional associations or conferences eligible for membership.

Seth G. Hess, *Chairman*

J. W. Wakefield, *Vice-Chairman*

W. Q. Kehr B. A. Poole W. W. Saxton

Sewage and Industrial Wastes Practice Committee

The Sewage and Industrial Wastes Practice Committee reviews and directs for publication any resolution, report, or publication which establishes professional or technical standards in the name of the Federation. The following Manuals of Practice have been published under the direction of the committee:

No. 1—Occupational Hazards in Sewage Works (1944)
No. 2—Utilization of Sewage Sludge as Fertilizer (1946)
No. 3—Municipal Sewer Ordinances (1949)
No. 4—Chlorination of Sewage and Industrial Wastes (1951)
No. 5—Air Diffusion in Sewage Works (1952)

Morris M. Cohn, *Chairman*

D. E. Bloodgood, *Vice-Chairman*

T. W. Clapham Kerwin L. Mick D. M. Pierce
E. B. Cobb F. W. Mohlman L. W. Van Kleeck
R. E. Fuhrman H. E. Orford F. M. Veatch
C. E. Keefer

Subcommittee on Sewer Maintenance

This subcommittee of the Sewage and Industrial Wastes Practice Committee has been directed to develop a Manual of Practice on "Maintenance of Sewers and Appurtenant Structures." The first draft of the manual is in preparation.

T. W. Clapham, *Chairman*

A. A. Appel, *Vice-Chairman*

N. S. Bubbis M. B. Nixon Sydney Preen
H. J. Graeser G. M. Olewiler C. S. Seabrook
J. L. Klamm L. E. West

Subcommittee on Standardization of Units

This subcommittee of the Sewage and Industrial Wastes Practice Committee has been assigned to develop an approved schedule of units to be used in the reporting of plant operation and laboratory data. A committee of about forty members is engaged in revising a preliminary draft.

H. E. Orford, *Chairman*

Subcommittee on Trickling Filters

This subcommittee of the Sewage and Industrial Wastes Practice Committee is engaged in the development of a Manual of Practice to be entitled "Trickling Filters—Their Characteristics and Loadings."

W. S. Mahlie, *Chairman*

B. F. Hatch Wm. E. Stanley Kenneth V. Hill

Subcommittee on Sewage Works Accounting

This subcommittee was created in 1946 for the purpose of developing a Manual of Practice on accounting procedures for municipal sewage works functions. Mimeographed copies of the manual in tentative form were made available for purchase in April, 1949.

F. M. Veatch, *Chairman*

G. J. Beiswanger
Alfred A. Estrada
E. A. Farmer
K. K. Wallace
S. I. Zack

Subcommittee on Paints and Protective Coatings

This subcommittee has the function of assembling experience and data on paints and protective coatings used in sewage works, to be presented with recommendations in the form of a manual. The subcommittee was created in 1946 and the first draft of the manual is now being prepared for critical review.

Kerwin L. Mick, *Chairman*

Virgil Anderson
J. W. Johnson
L. S. Kraus
W. T. McClenahan
F. W. Pinney
M. L. Robins
Walter A. Sperry

Subcommittee on Vacuum Filtration of Sludge

This subcommittee was created in 1951 for the purpose of developing a Manual of Practice on vacuum filtration of sewage sludge.

E. B. Cobb, *Chairman*

J. D. McDonald
W. E. Stanley
L. W. Van Kleeck

Subcommittee on Operation of Sewage Plants

This subcommittee was created in 1953 for the purpose of developing a Manual of Practice on sewage plant operation.

D. M. Pierce, *Chairman*

A. P. Troemper, *Vice-Chairman*

Ben Benas
W. M. Bingley
D. E. Bloodgood
P. N. Daniels
E. F. Eldridge
R. E. Fuhrman
G. E. Griffin
L. S. Kraus
W. S. Mahlie
A. H. Niles
H. G. Rogers
C. I. Sterling, Jr.
G. E. Symons
L. W. Van Kleeck

Subcommittee on Sewage Treatment Plant Design

The following Federation representatives were appointed in 1953 to serve jointly with representatives of the American Society of Civil Engineers in the production of a Manual of Practice.

T. R. Haseltine
G. E. Hubbell
M. H. Klegerman
G. W. Martin
F. D. Wraight

Subcommittee on Storm and Sanitary Sewer Design

The following Federation representatives were appointed in 1953 to serve jointly with representatives of the American Society of Civil Engineers in the production of a Manual of Practice.

C. G. Gaither
H. S. Smith
L. L. Sphar
C. R. Velzy
S. I. Zack

Research Committee

The Research Committee has the function of stimulating research work among the various Member Associations, and of cooperating with other organizations in the promotion of research.

H. Heukelekian, *Chairman*

R. Manganelli, *Vice-Chairman*

Subcommittee on the Annual Review of the Literature on Sewage, Waste Treatment, and Water Pollution

H. Heukelekian, *Chairman*

R. Manganelli, *Vice-Chairman*

H. Amberg
R. A. Canham
W. E. Dobbins
G. Edwards
M. B. Ettinger
D. G. Foulke
T. D. Furman
I. Gellman
A. E. Griffin
H. G. Harding
R. D. Hoak
W. M. Ingram
P. W. Kabler
M. Katz
F. W. Kittrell
R. J. McCabe
P. H. McGauhey
W. A. Moore
P. Mueller
R. Porges
E. R. Roth
L. Setter
A. J. Steffen
C. M. Tarzwell
G. H. Teletzke
W. W. Towne
H. A. Trebler
E. C. Tsivoglou
R. L. Woodward

Subcommittee on the Critical Review of the Literature on Toxicity of Industrial Wastes

H. Heukelekian, *Chairman*

G. E. Barnes
P. Doudoroff
G. P. Edwards
M. Katz
F. W. Kittrell
C. E. Renn
R. F. Weston

Subcommittee on the Development of Methods for the Toxicity Determinations on Wastes

R. S. Ingols, *Chairman*

D. E. Bloodgood
M. L. Cranstrom
T. Jaffe
N. L. Nemerow
M. L. Robins
W. W. Sanderson
C. N. Sawyer
J. H. Sorrels

Subcommittee on the Development and Standardization of Bio-assay Methods

P. Doudoroff, *Chairman*

B. G. Anderson
G. E. Burdick
P. S. Galstoff
W. B. Hart
R. Patrick
E. R. Strong
E. W. Surber
W. M. Van Horn

Finance Committee

The Finance Committee develops the annual operating budget of the Federation and affords guidance to the Board of Control in financial affairs.

W. J. Orchard, *Chairman*

H. E. Schlenz, *Vice-Chairman*

W. W. DeBerard E. C. Jensen G. W. Martin

Committee on Standard Methods of Sewage and Industrial Wastes Analysis

Created by the Board of Control on January 22, 1931, the Committee on Standard Methods of analysis was given constitutional status in October, 1953. The committee develops, perfects and modifies standard methods for the analysis of sewage and industrial wastes and of sludges or by-products therefrom. It also functions with similar committees of the American Water Works Association and American Public Health Association in the production of the laboratory manual *Standard Methods for the Examination of Water and Sewage*, the tenth edition of which was published early in 1955.

G. P. Edwards, *Chairman*

R. S. Ingols, *Vice-Chairman*

Ovid Baker
D. E. Bloodgood
A. M. Buswell
C. J. Carney
N. S. Chamberlin
R. V. Day
P. De Falco, Jr.
W. E. Dobbins
J. D. Fairing
K. Frashina
C. F. Gurnham
W. D. Hatfield
L. L. Hedgepeth
W. L. Henderson
H. Heukelekian
R. D. Hoak
E. F. Hurwitz
J. E. Kinney
R. R. Kountz
J. B. Lackey
V. Langworthy
G. W. Lawton
K. M. Mackenthun
H. C. Marks
W. Maske
R. G. McCall
J. A. McCarthy
M. G. Mellon
W. A. Moore
J. C. Morris
N. L. Nemerow
M. S. Nichols
F. E. Nussberger
T. R. Ostron
R. Pomeroy
M. L. Robins
G. A. Rohlich
W. W. Sanderson
C. N. Sawyer
L. R. Setter
C. M. Tarzwell
R. F. Weston

Industrial Wastes Committee

The Industrial Wastes Committee was created by the Board of Control on October 23, 1943, for the purpose of developing interest in this important field and to direct a program whereby the Federation may be of service in industrial waste problems.

R. W. Hess, *Chairman*

K. S. Watson, *Vice-Chairman*

E. B. Besselievre
H. H. Black
D. E. Bloodgood
J. L. Brown
G. Chanin
Harry Gehm
C. F. Gurnham
H. C. Ingerson
Kerry Mills
R. W. Ockershausen
L. F. Oeming
G. A. Pettit
H. T. Reuning
R. F. Rocheleau
R. E. Rostenbach
C. N. Sawyer
J. Wakefield
R. Weston
W. S. Wise

General Policy Committee

G. W. Martin, *Chairman*

D. B. Lee, *Vice-Chairman*

L. J. Fontenelli E. C. Jensen R. S. Rankin

Nominating Committee

The special Nominating Committee was created by the Board of Control on October 9, 1946, to function in an advisory capacity to the Election Committee. The Nominating Committee is to comprise the last five living Past Presidents, with the senior Past President as chairman.

Earnest Boyce, *Chairman*

E. Sherman Chase, *Vice-Chairman*

L. J. Fontenelli D. B. Lee G. W. Martin

SPECIAL COMMITTEES

Committee on Awards

The Committee on Awards was created by the Board of Control on October 11, 1941. Functions of the committee are to advise the Board on matters of award procedures and to make recommendations as to the annual winners of the Eddy, Gascoigne, Emerson, and Industrial Wastes medals.

R. E. Stiemke, *Chairman*

J. C. Dietz A. G. Pickett

Honorary Membership Committee

Authorized by the Board of Control on October 24, 1942, this committee is comprised of the President and four latest, living Past Presidents with the senior Past President as chairman. The committee reviews nominations for election to the grade of Honorary Member and makes recommendations to the Board on such nominations.

E. Sherman Chase, *Chairman*

L. J. Fontenelli D. B. Lee
E. C. Jensen G. W. Martin

Plant Operation Committee

This committee, formerly known as the Operation Reports Committee, was changed to the Plant Operation Committee by the 1954 Board of Control. The committee, which provides Federal recognition of outstanding operation reports, was created by the Board of Control on October 11, 1941. The committee now administers the William D. Hatfield Award.

M. E. Dawkins, *Chairman*

G. F. Bernauer W. D. Hatfield
W. M. Bingley C. W. Klassen

Operator's Qualifications Committee

Authorized by the Board of Control on October 11, 1941, the Operator's Qualifications Committee is assigned to "establish minimal qualifications for operators of various classes of treatment works." The committee also has the duty of collecting and compiling data on present procedures in the licensing and certification of operators for reference to Member Associations.

W. M. Bingley, *Chairman*

Sol Seid, *Vice-Chairman*

W. T. Ballard — Benjamin Benas — T. C. Schaetzle

Quarter Century Operators' Club Committee

The special Quarter Century Operators' Club Committee was created by the Board of Control on October 9, 1946. It is the function of this Committee to establish eligibility requirements, process membership applications, maintain the roster, and supervise the activities of the Quarter Century Operators' Club.

H. Van Der Vliet, *Chairman*

A. H. Niles — Harold W. Streeter

Legislative Analysis Committee

The Legislative Analysis Committee was created by the Board of Control on October 17, 1945, to study legislation pertinent to the interests of the Federation and to serve the Board in advisory capacity.

V. W. Bacon, *Chairman*

J. H. Allen — M. LeBosquet — R. S. Shaw
W. W. Gillespie — R. L .Winget

Constitution and Bylaws Committee

The Constitution and Bylaws Committee was created by the Board of Control on October 10, 1947, to review and develop recommendations for the amendment of the Constitution and Bylaws of the Federation as may be deemed advisable under changing conditions.

G. J. Schroepfer, *Chairman*

A. J. Fischer, *Vice-Chairman*

F. S. Friel — G. S. Russell — R. F. Weston
W. J. Orchard — W. H. Wisely

Safety Committee

This committee was created in 1954 for the purpose of maintaining close liaison between the Federation and the National Safety Council in the fields common to both organizations.

J. J. Wirts, *Chairman*

G. L. Burt — W. W. Mathews — H. A. Schreiber
U. T. Mann — L. W. Van Kleeck

Grade Membership Committee

M. L. Robins, *Chairman*

R. T. Antrim — D. R. Hill — Sol Seid
N. S. Bubbis — F. G. Nelson — L. Thompson
C. H. Connell — R. H. Ritter — J. W. Wakefield
C. E. Drummond — Roy Weston

JOINT COMMITTEES WITH OTHER ASSOCIATIONS

(Also see SEWAGE AND INDUSTRIAL WASTES PRACTICE COMMITTEE)

Joint Committee on Advancement of Sanitary Engineering

On October 5, 1952 the Board of Control authorized participation in the Joint Committee on Advancement of Sanitary Engineering with the American Society of Civil Engineers, American Water Works Association, American Public Health Association, and American Society for Engineering Education. The objectives of the committee are to study professional recognition of sanitary engineers, educational and training requirements, functional use in public health and military service, opportunities for employment, and similar matters.

FSIWA Representatives

R. E. Lawrence D. F. Metzler R. S. Rankin

Joint Committee on Chlorine Supply

On October 11, 1951, the Board of Control authorized participation in the Joint Committee on Chlorine Supply with the American Water Works Association and the Conference of State Sanitary Engineers. The objective of the committee is to study problems of chlorine supply and distribution in the water and sewage fields, and to develop recommendations for their solution.

FSIWA Representatives

L. H. Enslow L. L. Hedgepeth

Policy Advisory Committee, APHA Engineering Section

This joint committee was created in 1947 to advise the Council of the Engineering Section, American Public Health Association, on policies and activities of the Section relating to the field of environmental sanitation. Representation on the committee is held by national, regional, and state public health and sanitary engineering organizations.

FSIWA Representative

B. A. Poole

Joint Policy Committee

This joint committee was created in 1954 to provide a unified approach to problems or actions arising by reasons of emergencies or in the common interest. Representation on the committee is held by the Federation, the American Water Works Association, and the Water and Sewage Works Manufacturers' Association.

FSIWA Representatives

L. J. Fontenelli E. C. Jensen G. W. Martin
R. E. Fuhrman D. B. Lee W. J. Orchard

SPECIAL CONVENTION COMMITTEES

Convention Management Committee

The function of this committee is to supervise details of the management of the Annual Meetings of the Federation.

T. T. Quigley, *Chairman*

J. A. Frank
R. E. Fuhrman
C. N. Sawyer
J. G. Stewart

Meeting Place Committee

This committee reviews invitations received for the Annual Meetings of the Federation and makes recommendations to the Board of Control in regard to the time and place of such meetings.

E. C. Jensen, *Chairman*

J. A. Frank
R. E. Fuhrman
G. W. Martin
H. E. Schlenz
J. G. Stewart
K. S. Watson

MEMBERSHIP SUMMARY

(As of December 31, 1956)

Federation Members

Honorary Members	14
Associate Members	75
Member Associations	38
Active Members	6,894
Corporate Members	194

Net Membership of Member Associations *

Member Association	Active	Honorary	Corporate	Total
Alabama	43	—	3	46
Arizona	36	—	4	40
Arkansas	58	—	—	58
California	603	1	7	611
Canadian Institute	487	1	1	489
Central States	664	3	34	701
Dakota	37	—	—	37
Federal	76	—	—	76
Florida	261	1	—	262
Georgia	102	—	1	103
Germany	37	1	—	38
Iowa	122	—	—	122
IPHE (England)	38	—	—	38
ISP (England)	133	1	—	134
Kansas	109	—	1	110
Kentucky-Tennessee	179	—	4	183
Louisiana	16	—	—	16
Maryland-Delaware	71	—	—	71
Michigan	398	—	2	400
Missouri	55	—	—	55
Montana	33	—	4	37
Nebraska	68	—	6	74
New England	391	2	1	394
New Jersey	258	1	—	259
New York	605	1	21	627
North Carolina	163	—	—	163
Ohio	342	—	35	377
Oklahoma	55	—	—	55
Pacific Northwest	312	—	—	312
Pennsylvania	484	1	30	515
Puerto Rico	44	—	—	44
Rocky Mountain	74	—	4	78
South Carolina	47	—	1	48
Sweden	92	—	—	92
Switzerland	15	—	—	15
Texas	200	—	3	203
Virginia	112	—	17	129
West Virginia	75	—	15	90
Totals	6,895	13	194	7,102

* Not including Dual Members.

MEMBER ASSOCIATIONS

Alabama Water and Sewage Association—Sewage Works Section (Affiliated 1948).

Territory: State of Alabama.
President: H. O. Snow; *Vice-President:* G. McAlily; *Director:* J. L. Crockett, Jr.; *Treasurer:* W. H. Gilmore; *Secretary:* Robert Tindall, P.O. Box 1224, University, Ala.

Arizona Sewage and Water Works Association—Sewage Works Section (Affiliated 1928).

Territory: State of Arizona.
President: M. V. Ellis; *First Vice-President:* Q. M. Mees; *Second Vice-President:* T. Nesbitt; *Director:* J. A. Carollo; *Secretary-Treasurer:* H. C. Bigglestone, Board of Fire Underwriters, Phoenix, Ariz.

Arkansas Water and Sewage Conference—Sewage Works Section (Affiliated 1946).

Territory: State of Arkansas.
Chairman: John Luce; *Vice-Chairman:* Foster Burba; *Director:* L. R. Heiple; *Secretary-Treasurer:* Dr. C. W. Oxford, Univ. of Arkansas, Fayetteville, Ark.

California Sewage and Industrial Wastes Association (Affiliated 1928).

Territory: State of California.
President: E. V. Quartly; *First Vice-President:* John Maga; *Second Vice-President:* R. Bargman; *Directors:* R. T. Antrim and J. H. Peterson; *Secretary-Treasurer:* Robert J. Barletta, 719 South Loara St., Anaheim, Calif.

Canadian Institute on Sewage and Sanitation (Affiliated 1933).

Territory: Dominion of Canada.
President: L. B. Allan; *Vice-President:* R. V. Anderson; *Director:* C. A. Anderson; *Secretary-Treasurer:* A. E. Berry, Administrative Office, 72 Grenville St., Toronto 8, Ont., Can.

Central States Sewage and Industrial Wastes Association (Affiliated 1928).

Territory: States of Illinois, Indiana, Wisconsin, and Minnesota.
President: W. E. Ross; *First Vice-President:* A. P. Troemper; *Second Vice-President:* R. W. Frazier; *Third Vice-President:* L. H. Smith; *Director:* M. L. Robins; *Secretary-Treasurer:* George F. Bernauer, 713 Chapman St., Madison, Wis.

Dakota Water and Sewage Works Conference—Sewage Works Sections (Affiliated 1936).

North Dakota Section

Territory: State of North Dakota.
President: E. D. Peterson; *Vice-President:* H. J. Arnold; *Director:* L. W. Veigel; *Secretary-Treasurer:* Jerome H. Svore, c/o State Dept. of Health, Bismarck, N. Dak.

South Dakota Section

Territory: State of South Dakota.
President: L. Haddorff; *Vice-President:* R. Heiens; *Director:* L. W. Veigel; *Secretary-Treasurer:* Charles E. Carl, c/o Div. of Sanitary Engineering, State Board of Health, Pierre, S. Dak.

Federal Sewage Research Association (Affiliated 1930).

Territory: Federal employees wherever stationed.
President: S. C. Martin; *Vice-President:* P. Doudoroff; *Director:* appointment pending; *Secretary-Treasurer:* Keith S. Krause, 9th Floor, 1114 Commerce St., Dallas 2, Texas.

Florida Sewage and Industrial Wastes Association (Affiliated 1941).

Territory: State of Florida.
President: D. B. Smith; *Vice-President:* J. J. R. Bristow; *Director:* J. W. Wakefield; *Secretary-Treasurer:* Ralph H. Baker, Jr., Fla. State Bd. of Health, P.O. Box 210, Jacksonville, Fla.

Georgia Water and Sewage Association—Sewage Works Section (Affiliated 1936).

Territory: State of Georgia.
President: F. L. Futral; *First Vice-President:* M. B. Nixon; *Second Vice-President:* A. B. Culverhouse; *Director:* R. E. Stiemke; *Secretary-Treasurer:* A. T. Storey, 1210 Hemphill Ave., N.W., Atlanta, Ga.

German Sewage Technologists Association (Affiliated 1950).

(Abwassertechnische Vereinigung)
Territory: Western Germany.
President: F. Schreier; *First Vice-President:* Wilhelm Husman; *Second Vice-President:* Hans Koster; *Director:* Dr. Ing. Schmitz-Lenders; *Secretary-Treasurer:* O. Pallasch, Theaterstrasse 24, Bonn, Germany.

Institute of Sewage Purification—England (Affiliated 1932).

Territory: British Empire.
President: C. E. Burke; *First Vice-President:* S. H. Jenkins; *Second Vice-President:* W. A. Hiller; *Director:* M. Lovett; *Treasurer:* L. B. Phillips; *Secretary:* W. F. A. Snook, 10 Cromwell Place, South Kensington, London, S. W. 7, England.

Institution of Public Health Engineers—England (Affiliated 1932).

Territory: British Empire.
President: J. T Calvert; *Vice-President:* N. J. Tatman; *Director:* M. A. Kershaw; *Treasurer:* A. Seiver; *Secretary:* Ernest V. Balsom, 118 Victoria St., Westminster, S.W. 1, London, England.

Iowa Sewage and Industrial Wastes Association (Affiliated 1928).

Territory: State of Iowa.
President: K. Hirlinger; *Vice-President:* H. S. Smith; *Director:* H. F. Seidel; *Secretary-Treasurer:* L. F. Skorczeski, 207 South 15th Ave., Marshalltown, Iowa.

Kansas Sewage and Industrial Wastes Association (Affiliated 1935).

Territory: State of Kansas.
Chairman: D. Eller; *Vice-Chairman:* V. Pickering; *Second Vice-Chairman:* S. M. Smith; *Director:* M. Nelson; *Secretary-Treasurer:* James F. Aiken, 407 City Bldg., Wichita, Kans.

Kentucky-Tennessee Industrial Wastes and Sewage Works Association (Affiliated 1946).

Territory: States of Kentucky and Tennessee.
Chairman: L. F. Birkel; *Vice-Chairman:* W. H. Owens; *Director:* G. S. Bell; *Secretary-Treasurer:* S. Leary Jones, 420 Sixth Ave., N., Nashville 3, Tenn.

Louisiana Conference on Water Supply and Sewerage—Sewage Works Section (Affiliated 1949).

Territory: State of Louisiana.
Chairman: L. B. Bankston; *Vice-Chairman:* A. A. Hirsch; *Director:* J. L. Love; *Secretary-Treasurer:* George H. West, P. O. Box 15, Lake Charles, La.

Maryland-Delaware Water and Sewage Association—Sewage Works Section (Affiliated 1928).

Territory: States of Maryland and Delaware.
President: J. Krasauskas; *First Vice-President:* R. H. Hartman; *Second Vice-President:* E. Craft; *Director:* R. H. Ritter; *Secretary-Treasurer:* W. M. Bingley, 2411 N. Charles St., Baltimore 18, Md.

Michigan Sewage and Industrial Wastes Association (Affiliated 1930).

Territory: State of Michigan.
President: M. Groen; *First Vice-President:* H. J. Hayward; *Second Vice-President.* R. J. Peterson; *Director:* R. A. Greene; *Secretary-Treasurer:* D. M. Pierce, Michigan Dept. of Health, Room 334, Administration Bldg., Lansing 4, Mich.

Missouri Water and Sewerage Conference—Sewage Works Section (Affiliated 1929).

Territory: State of Missouri.
Chairman: F. McAndrew; *Vice-Chairman:* R. Hayob; *Director:* J. K. Smith; *Secretary-Treasurer:* Warren A. Kramer, c/o State Office Bldg., Sixth Floor, Jefferson City, Mo.

Montana Sewage and Industrial Wastes Association (Affiliated 1944).

Territory: State of Montana.
Chairman: Verne Reed; *Vice-Chairman:* Claude Eyer; *Director:* D. H. Denman; *Secretary-Treasurer:* Harvey W. Taylor, Morrison & Maierle, Inc., Helena, Mont.

Nebraska Sewage and Industrial Wastes Association (Affiliated 1952).

Territory: State of Nebraska.
President: V. H. Black; *Vice-President:* Lloyd Thomas; *Director:* D. R. Hill; *Secretary-Treasurer:* V. J. Lechtenberg, 614 Standard Oil Bldg., Omaha, Nebr.

New England Sewage and Industrial Wastes Association (Affiliated 1929).

Territory: States of Maine, New Hampshire, Vermont, Massachusetts, Connecticut, and Rhode Island.
President: C. N. Sawyer; *First Vice-President:* J. McDonald; *Second Vice-President:* H. F. Munroe; *Director:* W. S. Wise; *Secretary-Treasurer:* Earl R. Howard, 115 Broad St., Hartford 5, Conn.

New Jersey Sewage and Industrial Wastes Association (Affiliated 1942).

Territory: State of New Jersey.
President: John Collom; *First Vice-President:* A. Palmer; *Second Vice-President:* R. J. Budrick; *Director:* S. Seid; *Secretary-Treasurer:* Michael S. Kachorsky, P. O. Box 766, Manville, N. J.

New York Sewage and Industrial Wastes Association (Affiliated 1930).

Territory: State of New York.
President: R. Thomas; *Vice-President:* F. Cramer; *Directors:* A. J. Fischer and Uhl T. Mann; *Treasurer:* J. C. Brigham; *Secretary:* R. C. Sweeney, c/o State Dept. of Health, 21 N. Broadway, White Plains, N. Y.

North Carolina Sewage and Industrial Waste Association (Affiliated 1929).

Territory: State of North Carolina.
Chairman: Carl W. Mengel; *Vice-Chairman:* W. F. Stokes; *Director:* E. C. Hubbard; *Secretary-Treasurer:* W. E. Long, Jr., Box 2091, Raleigh, N. C.

Ohio Sewage and Industrial Wastes Treatment Conference (Affiliated 1932).

Territory: State of Ohio.
Chairman: F. Ruck; *First Vice-Chairman:* W. R. Taylor; *Second Vice-Chairman:* C. Bauer; *Director:* G. A. Hall; *Secretary-Treasurer:* Ward E. Conrad, 301 Ohio Depts. Bldg., Columbus 15, Ohio.

Oklahoma Water, Sewage and Industrial Waste Conference—Sewage Works Section (Affiliated 1929).

Territory: State of Oklahoma.
President: J. K. Lindsey; *Vice-President:* R. G. Wampler; *Director:* G. L. Morris; *Secretary-Treasurer:* H. M. Crane, State Dept. of Health, 3400 N. Eastern, Oklahoma City 5, Okla.

Pacific Northwest Sewage and Industrial Wastes Association (Affiliated 1933).

Territory: States of Washington, Oregon, and Idaho.
President: A. J. Wahl; *Vice-President:* R. T. Smith; *Director:* H. L. Thompson; *Secretary-Treasurer:* Gilbert H. Dunstan, P. O. Box 176, Pullman, Wash.

Pennsylvania Sewage and Industrial Wastes Association (Affiliated 1928).

Territory: State of Pennsylvania.
President: G. A. Elias; *First Vice-President:* B. S. Bush; *Second Vice-President:* H. McElhaney; *Director:* R. F. Weston; *Secretary-Treasurer:* J. R. Harvey, Regional San. Engr., Pennsylvania Dept. of Health, 916 Diamond, Meadville, Pa.

Puerto Rico Water and Sewage Works Association (Affiliated 1947).

Territory: Puerto Rico.
President: G. F. Garcés; *Vice-President:* E. Martinó; *Director:* R. Domenech; *Secretary-Treasurer:* Robert J. Auld, c/o Puerto Rico Aqueduct and Sewer Authority, Box 2832, San Juan 12, Puerto Rico.

Rocky Mountain Sewage Works Association (Affiliated 1947).

Territory: States of Wyoming, Colorado, and New Mexico.
President: Robert P. Lowe; *Vice-President:* H. V. Lewis; *Director:* B. V. Howe; *Secretary-Treasurer:* John R. Peterson, 376 City and County Bldg., Denver 2, Colo.

South Carolina Water and Sewage Works Association—Sewage Works Section (Affiliated 1949).

Territory: State of South Carolina.
Chairman: M. Beach; *Vice-Chairman:* W. G. Crosby; *Director:* E. D. Fry, Jr.; *Secretary-Treasurer:* T. P. Anderson, Div. of San. Eng., State Bd. of Health, Columbia, S. C.

Swedish Association for Water Hygiene (Affiliated 1952).
(Föreningen För Vattenhygien)

Territory: Sweden.
President: A. Myrgård; *Vice-President:* M. Wennström; *Director:* G. Akerlindh; *Secretary-Treasurer:* Erik Jonsson, Box 5038, Stockholm 5, Sweden.

Swiss Association of Water and Sewage Professionals (Affiliated 1947).
(Verband Schweizerischer Abwasserfachleute)

Territory: Switzerland.
President: P. Wildi; *Director:* P. Wildi; *Treasurer:* E. Holinger; *Secretary:* G. Kisseleff, Wegmann Cons. Engrs., Limberstr. 16, Kusnacht, Zurich, Switzerland.

Texas Water and Sewage Works Association—Sewage and Industrial Wastes Section (Affiliated 1928).

Territory: State of Texas.
Chairman: G. A. Doty; *First Vice-Chairman:* E. W. Wallentine; *Second Vice-Chairman:* R. Moehlman; *Director:* C. H. Connell; *Secretary:* V. M. Ehlers, 2202 Indian Trail, Austin, Tex.; *Assistant Secretary and Treasurer:* Mrs. E. H. Goodwin.

Virginia Industrial Wastes and Sewage Works Association (Affiliated 1947).

Territory: State of Virginia.
President: J. J. Corbalis, Jr.; *Vice-President:* J. P. Kavanaugh; *Director:* F. H. Miller; *Secretary-Treasurer:* J. L. Hamrick, Jr., 415 W. Franklin St., Richmond 20, Va.

West Virginia Sewage and Industrial Wastes Association (Affiliated 1947).

Territory: State of West Virginia.
President: J. W. Lester; *First Vice-President:* P. T. Arbuckle; *Second Vice-President:* H. W. Pitts; *Director:* O. C. Thompson; *Secretary-Treasurer:* Glen O. Fortney, State Dept. of Health, Charleston 5, W. Va.

HONORARY MEMBERS *

Berry, Albert E. (1954), Dir., Ont. Dept. of Health, San. Eng. Div., 235 Gainsboro Rd., Toronto 8, Ont., Can. (Can.)

DeBerard, Wilford Willis (1950), Dep. Commr. of Water and Chf. Water Engr., Bur. of Eng., Dept. of Pub. Works, 402 City Hall, Chicago 2, Ill (Cen. St.)

Fair, Gordon Maskew (1955), Head, Dept. of San. Eng., Harvard Univ., Cambridge 38, Mass. (N. Eng.)

Gilcreas, F. Wellington (1948), Prof. of San. Sc., Univ. of Fla., Gainesville, Fla. (N. Eng.)

Hyde, Charles Gilman (1943), Cons. Engr., 2599 Buena Vista Way, Berkeley 8, Calif. (Calif.)

Imhoff, Karl (1953), Cons. Eng., Robert Schmidt Str. 8, Essen, Germany (Germany)

Lockett, William T. (1954), Chf. Chemist, Mogden Purification Works, Oak Lane, Isleworth, Middlesex, Eng. (ISP)

Mohlman, Dr. Floyd W. (1944), Dir., Div. of Lab., Met. San. Dist. of Greater Chicago, 100 E. Erie St., Rm. 301, Chicago 11, Ill. (Cen. St.)

Moses, Howard E. (1943), Cons. Engr., State Dept. of Health, 1522 N. Second St., Harrisburg, Pa. (Pa.)

Orchard, William J. (1946), Wallace & Tiernan Co., Inc., Newark 1, N. J. (N.Y.)

Rudolfs, Willem (1945), Huzarenlaan, Joppe (Geld), The Netherlands (N.J.)

Streeter, Harold W. (1953), Box 192, R.R. 1, Old Indian Hill Rd., Cincinnati 27, Ohio (Fed.)

Wiseley, W. H. (1956), Exec. Sec.-Ed., American Soc. of Civ. Eng., 33 W. 39th St., New York 18, N. Y. (Cen. St.)

* Year of election to Honorary Membership and Member Association affiliation shown in parentheses.

ASSOCIATE MEMBERS

Airkem, Inc., 241 East 44th St., New York 17, N. Y., Rep. J. M. von Bergen.

American Cast Iron Pipe Co., Birmingham, Ala., Rep. A. J. Hellman.

American City Magazine, 470 Fourth Ave., New York, N. Y., Rep. Edgar J. Buttenheim, Pres.

American Concrete Pipe Assn., 228 N. LaSalle St., Suite 1033, Chicago 1, Ill., Rep. Howard F. Peckworth, Managing Dir.

American Pipe and Construction Co., P. O. Box 3428, Terminal Annex, Los Angeles 54, Calif., Rep. V. L. Greedy, Div. Sales Mgr.

American Well Works, 100 N. Broadway, Aurora, Ill., Rep. L. H. Kramer, Exec. Vice-Pres.

Armco Drainage & Metal Products, Inc. (Armco Steel Corp.), Middletown, Ohio, Rep. W. H. Spindler, Pub. Mgr.

Atlas Mineral Products Co., Mertztown, Pa., Rep. Donald F. Deakin, Sales Mgr., Water and Sewer Materials.

B-I-F Industries, Inc., 345 Harris Ave., Providence, R. I., Rep. G. W. Kelsey, Vice-Pres.

Carter, Ralph B., Co., 192 Atlantic St., Hackensack, N. J., Rep. J. J. Horgan.

Chain Belt Co., P. O. Box 2022, Milwaukee 1, Wis., Rep. R. T. Steindorf.

Chapman Valve Mfg. Co., 203 Hampshire St., Indian Orchard, Mass., Rep. John H. Sheehan.

Chicago Pump Co., 622 Diversey Parkway, Chicago 14, Ill., Rep. Milton Spiegel, Vice-Pres.

Climax Engine and Pump Mfg. Co., 208 S. LaSalle St., Chicago 4, Ill., Rep. E. D. West, Mgr.

Combustion Engineering, Inc., Raymond Pulverizer Div., 1315 N. Branch St., Chicago 22, Ill., Rep. C. W. Gordon, Mgr.

DeZurik Shower Co., Sartell, Minn., Rep. David DeZurik.

Dorr-Oliver Inc., Barry Pl., Stamford, Conn.

Dow Chemical Co., Technical Service and Development, Midland, Mich., Rep. Robert F. Ryan.

Elmco Corp., 301 S. Hicks Rd., Palatine, Ill., Rep. Paul O. Richter, Mgr., Central Div.

Engineering News-Record, 330 W. 42nd St., New York 36, N. Y.

Everson Mfg. Co., 214 W. Huron St., Chicago 10, Ill., Rep. R. B. Everson, Pres.

Fairbanks, Morse & Co., 3601 Kansas Ave., Kansas City, Kans., Rep. T. E. Woodruff.

Fischer & Porter Co., Hatboro, Pa., Rep. Jack Burke.

Flexible Sales Corp., 3786 Durango Ave., Los Angeles 34, Calif., Rep. Peter L. Ciaccio, Mgr.

Foxboro Co., Util. Ind. Div., Foxboro, Mass., Rep. Russell H. Babcock, Asst. Mgr.

Gale Separator Co., Inc., 2 Broad St., Bloomfield, N. J., Rep. William A. Gehle, Pres.

General Electric Co., 1 River Rd., Schenectady 5, N. Y., Rep. E. O. Pothoff.

General Laboratory Supply Co., P. O. Box 2607, Paterson, N. J., Rep. I. T. Klein.

Gruendler Crusher & Pulverizer Co., 2915 N. Market St., St. Louis 6, Mo., Rep. William P. Gruendler.

Hardinge Co., York, Pa., Rep. M. C. Fleming.

Hersey Mfg. Co., Corner of E. and Second Sts., S. Boston 27, Mass., Rep. William C. Sherwood.

Homelite, Port Chester, N. Y., Rep. Robert P. Straetz.

Homestead Valve Mfg. Co., Box 348, Coraopolis, Pa., Rep. F. E. Schuchman.

Industrial Materials Co., Somerset St. & Trenton Ave., Philadelphia 34, Pa., Rep. John M. Riordan, Pres.

Inertol Co., Inc., 480 Frelinghuysen Ave., Newark 5, N. J., Rep. G. W. Rupp.

Infilco Inc., 901 S. Campbell Ave., P. O. Box 5033, Tucson, Ariz., Rep. W. H. Gillard.

Jeffrey Mfg. Co., Columbus 16, Ohio, Rep. S. L. Tolman.

Johns-Manville Corp., 22 E. 40th St., New York 16, N. Y., Rep. R. F. Orth.

Josam Mfg. Co., Michigan City, Ind., Rep. Leo N. Newman.

Komline-Sanderson Eng. Corp., P. O. Box 257, Peapack, N. J., Rep. T. R. Komline, Pres.

Koppers Co., Inc., Tar Products Div., Pittsburgh 19, Pa., Rep. M. K. Cox.

Lakeside Eng. Corp., 222 W. Adams St., Chicago 6, Ill.

Link-Belt Co., Colmar Plant, Colmar, Pa., Rep. B. K. Hartman.

Lock Joint Pipe Co., E. Orange, N. J., Rep. F. F. Longley, Vice-Pres.

Mine Safety Appliances Co., Braddock, Thomas & Meade Sts., Pittsburgh 8, Pa., Rep. N. R. Chillingworth.

Minneapolis-Honeywell Regulator Co., Wayne & Windrim Aves., Philadelphia 44, Pa., Rep. W. H. Sisson, Industry Mgr.

Morse Boulger Destructor Co., Sewage & Waste Div., 80 Fifth Ave., New York 11, N. Y.

Mueller Co., 512 W. Cerro Gordo St., Decatur, Ill., Rep. R. H. Morris.

National Water Main Cleaning Co., 50 Church St., New York, N. Y., Rep. J. A. Frank, Pres.

Nichols Eng. & Research Corp., 60 Wall Tower, New York 5, N. Y., Rep. R. W. Rowen.

Pacific Flush Tank Co., 4241 Ravenswood Ave., Chicago, Ill., Rep. L. E. Rein.

Penn Instruments Division, Burgess Manning Co., 4110 Haverford Ave., Philadelphia 4, Pa., Rep. Wm. C. Bennett.

Pittsburgh Coke and Chemical Co., P. O. Box 1645, Pittsburgh 30, Pa., Rep. J. G. Birch.

Pittsburgh-Des Moines Co., Neville Island Branch, Pittsburgh 25, Pa., Rep. L. E. O'Leary.

Pittsburgh Equitable Meter Division, Rockwell Manufacturing Co., 400 N. Lexington Ave., Pittsburgh, Pa., Rep. J. F. O'Grady.

Preload Co., Inc., 211 E. 37th St., New York 16, N. Y., Rep. E. H. Thwaits, Vice-Pres.

Price Brothers Co., 1932 E. Monument Ave., P. O. Box 825, Dayton 1, Ohio, Rep. Harry S. Price, Jr.

Public Works Magazine, 200 S. Broad St., Ridgewood, N. J., Rep. W. A. Hardenbergh.

Simplex Valve & Meter Co., 7 E. Orange St., Lancaster, Pa., Rep. Everett M. Jones, Sales Mgr.

Smith, A. P., Mfg. Co., 545 N. Arlington Ave., E. Orange, N. J. Rep. W. P. Baerenrodt.

Smith and Loveless, Inc., 62nd and Merriam Dr., Merriam, Kans., Rep. B. Alden Smith.

Stuart Corp., 516 N. Charles St., Baltimore, Md., Rep. Fred E. Stuart, Sr.

Vapor Recovery Systems Co., 466 M and M Bldg., Houston, Tex., Rep. F. V. Long, Pres.

Walker Process Equipment, Inc., Aurora, Ill., Rep. J. D. Walker, Pres.

Wallace & Tiernan Co., Inc., 25 Main St., Belleville 9, N. J., Rep. T. T. Quigley.

Warren Foundry & Pipe Corp., 55 Liberty St., New York 5, N. Y., Rep. Frank Marold.

Wastes Engineering, 305 E. 45th St., New York 17, N. Y., Rep. Karl M. Mann.

Water & Sewage Works, 185 N. Wabash Ave., Chicago 1, Ill., Rep. E. S. Gillette.

Western City Magazine, 440 Statler Bldg., Los Angeles 17, Calif., Rep. Winston R. Updegraff.

Western Machinery Co., 760 Folsom St., San Francisco 7, Calif., Rep. Wm. H. Newton.

Westinghouse Electric Corp., P. O. Box 146, Pittsburgh 30, Pa., Rep. J. D. Witherspoon.

W-K-M Mfg. Co., Inc., Div. of ACF Industries, Inc., P. O. Box 2117, Houston 1, Tex., Rep. William A. Gormley.

Wood, R. D., Co., Public Ledger Bldg., Independence Square, Philadelphia 5, Pa., Rep. T. W. Wood.

Worthington Corp., Harrison, N. J., Rep. C. K. Hood, Vice-Pres.

Yeomans Brothers Co., 1999 N. Ruby St., Melrose Park, Ill., Rep. Charles Yeomans, Pres.

SUPPLEMENTAL MEMBERSHIP DIRECTORY *

The last full membership listing, published in the March 1956 issue of THIS JOURNAL, gave the membership roster of Member Associations as of December 31, 1955. This supplemental listing, therefore, includes only the names and addresses of those who have been added to that previous listing as new or reinstated members during 1956 and therefore were not included in the main biennial listing.

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CONSTITUTION AND BYLAWS

FEDERATION OF SEWAGE AND INDUSTRIAL WASTES ASSOCIATIONS

Adopted January 15, 1941. As amended to October 7, 1956.

CONSTITUTION

ARTICLE I. Name

The name of this organization shall be the Federation of Sewage and Industrial Wastes Associations, hereinafter designated as the Federation.

ARTICLE II. Objectives

The objectives of this Federation shall be: The advancement of fundamental and practical knowledge concerning the nature, collection, treatment and disposal of sewage and industrial wastes; the design, construction, operation and management of sewer systems and treatment works; the study, promotion and encouragement of improved sanitation of waterways; the correlation and strengthening of regional and state sewage and industrial wastes associations or conferences within or without the United States of America; the publication of a journal; and other relevant activities.

ARTICLE III. Membership

The membership of the Federation shall consist of regional or state associations or conferences, either within or without the territory of the United States of America, hereinafter designated as Member Associations, whose objectives and constitutions are in harmony with the purposes of this Federation, and of individuals or corporations as specified in the Bylaws, subject to the conditions and limitations prescribed in the Constitution and Bylaws of the Federation.

ARTICLE IV. Organization

SECTION 1. The affairs of the Federation shall be conducted by a Board of Control (hereinafter designated as the Board) under such rules as the Board may determine, subject to the specific conditions of this Constitution and Bylaws.

SECTION 2. The officers of the Federation shall be a President, a Vice-President, a Secretary, and a Treasurer.

SECTION 3. The Board shall consist of:

(a) The President of the Federation.
(b) The Vice-President of the Federation.
(c) The Treasurer of the Federation.
(d) One Director to be appointed by and to represent each Member Association. One additional Director to be named by each Member Association which has maintained a total Active plus Corporate membership of 500 or more for the three preceding successive years ending on September 30.
(e) Six Directors-at-Large, of whom three are to be elected by the Board of Governors of the Water and Sewage Works Manufacturers Association, and three by the Directors representing the Member Associations.
(f) The latest living Past President of the Federation.

SECTION 4. The terms of office of the President, Vice-President, and Treasurer shall be one year, and the Directors three years, which terms shall start at the beginning of the last session of the Annual Meeting of the Board at which they are elected and continue until a successor qualifies. The Secretary shall be appointed by the Board for the term of office stated in the Bylaws. In the case of a vacancy in the office of President, the Vice-President shall act in his place for the unexpired term. In case the Vice-President cannot act, the latest living Past President shall do so. In the case of a vacancy in the office of Treasurer or of any Director-at-Large representing Member Associations, the Executive Committee shall appoint an Active Member to fill such office for the unexpired term. Any vacancy occurring among the Directors-at-Large elected by the Manufacturers Association shall be filled by the Board of Governors of that Association.

SECTION 5. The President shall be ineligible for re-election. The Vice-President and Directors shall not be eligible for reappointment or for re-election to the same office until at least one full term shall have elapsed after the end of their respective terms.

SECTION 6. The President of the Federation shall be the Presiding Officer of the Board.

SECTION 7. A quorum of the Board shall consist of a majority of its ex-officio members, Directors-at-Large, and those Directors representing Member Associations within the territory of the United States of America and of Canada. Any member of the Board, except the President, Vice-President, or Treasurer may designate a proxy to act for him if he is unable to attend a meeting in person. Such proxies shall be designated in writing by the absentee Board member from the same Member Association, or organization he represents. All such proxies shall be counted in determining a quorum. Only in the event of a lack of a quorum at an Annual Meeting shall the chair be authorized to appoint proxies and then only from the absentee Member Association or organization, if such representation is available. In no case shall any individual cast more than one vote.

ARTICLE V. Nomination and Election of Officers and Directors

SECTION 1. The Annual Meeting of the Board shall be held during the Annual Convention of the Federation on such day or days as may be decided by the Board. In event there is no Annual Convention of the Federation the Annual Meeting of the Board shall be in the office of the Federation on the third Saturday in October. Other meetings of the Board may be held as provided in the Bylaws.

At the Annual Meeting the Directors representing the Member Associations shall meet under the chairmanship of the President of the Federation, and shall by a majority vote of all such Directors voting, elect a President, Vice-President, Treasurer and one Director-at-Large. Absent Directors may vote by proxy, in accordance with procedure defined in Article IV, Section 7 of this Constitution. Any candidate so elected shall be an Active Member of some Member Association and shall signify willingness to serve. Any candidate elected as President or Vice-President shall at some time previous to such election have been a member of the Board of Control.

SECTION 2. One Director on the Board of Control to represent each Member Association shall be elected by each Member Association. One additional Director is to be elected by each Member Association which has maintained a total Active plus Corporate membership of 500 or more, for the preceding three successive years ending on September 30. Each Director so elected shall be an Active Member of the respective Member Association and in good standing at the time of his election.

In the case of any Director, representing a Member Association, retiring for any cause before his term is completed, or who fails to remain in good standing in his Member Association, the governing board of the Member Association shall designate his successor, who shall serve for the unexpired portion of his term.

ARTICLE VI

Except as specifically mentioned herein, this Constitution shall take effect immediately upon its adoption by the Board of Control.

ARTICLE VII. Amendments

Amendments to this Constitution may be made by a two-thirds vote of the total membership of the Board present or represented by proxy, notice of the proposed amendment having been given to each member of the Board and to the Secretary of each Member Association not less than sixty days in advance of the meeting, at which the said amendments are to be voted upon.

BYLAWS

ARTICLE I. Member Associations

SECTION 1. Any regional or state association or conference, or other organization whose objectives and constitution are in harmony with those of the Federation, may be granted membership in the Federation by a majority vote of the Board; provided, that the constitution of the applicant association or conference has been examined and certified by the Board as being in accord with Article III of the Constitution of this Federation; and provided further, that certification shall be made by the association seeking admission to membership that the Constitution and Bylaws of the Federation are accepted by it.

SECTION 2. Any Member Association may withdraw from the Federation at the end of any fiscal year by giving three months' notice of such intention, provided that the dues of such Member Association in the Federation are fully paid up to time of withdrawal.

SECTION 3. Any Member Association may be excluded from this Federation, at the pleasure of the Board, for non-payment of dues, as hereinafter provided, or for any change in its constitution that may bring it into conflict with the Constitution or Bylaws of the Federation.

SECTION 4. Any change in the existing constitution or bylaws of a Member Association shall be reported in full to the Secretary of the Federation within thirty days after its adoption by said Member Association.

ARTICLE II. Classification of Members

SECTION 1. Membership of the Federation shall be composed of Member Associations, Honorary Members, Associate Members and Sustaining Members. Membership in the Member Associations shall consist of Active Members and Corporate Members only.

SECTION 2. An Active Member shall be a superintendent, manager, operator, or employee of a sewage or industrial wastes system or treatment works; a professional engineer; a chemist, bacteriologist, biologist, or any qualified person professionally engaged or interested in the advancement of knowledge relating to the disposal or treatment of sewage and industrial wastes or improved sanitation of waterways.

SECTION 3. A Corporate Member shall be a Sewerage Board, Department or Commission; Sanitary District; Department of Public Works handling sewerage; Industrial Corporation; National, State, District or Municipal Board or Department of Health; or other body, corporation or organization engaged or interested in at least one of the stated objectives of the Federation, and shall be entitled to one representative whose name shall appear on the roll of members and who shall have all the rights and privileges of an Active Member. This representative may be changed at the convenience and pleasure of the Corporate Member on written notice to the Secretary of the Member Association to which the Corporate Member is accredited.

SECTION 4. An Honorary Member shall be a person of acknowledged eminence in one or more fields of activity within the scope of the stated objectives of the Federation. Candidates may be nominated by any Member Association or by a special committee appointed by the Board but can be elected only by favorable secret ballot vote of the Board. Two negative votes shall exclude. No election to Honorary Membership shall be made which would cause the total number of Honorary Members to exceed a ratio of one Honorary Member to every 350 Active Members. Not more than two Honorary Members shall be elected in any calendar year. Honorary Members shall be elected for life, shall pay no dues, and shall receive, without cost, all the publications of the Federation that are distributed to its members.

SECTION 5. An Associate Member shall be a person, firm, or corporation engaged in the manufacturing or furnishing of supplies, materials, or equipment for the construction, operation or maintenance of sewage or industrial waste facilities, and shall be elected by affirmative vote of a majority of the Board after consideration of written application duly made to the Secretary.

SECTION 6. A Sustaining Member shall be an individual or a corporation interested in the general objectives of the Federation.

ARTICLE III. Dues

SECTION 1. The status and dues of the different classes of members established by the Member Associations, as applied to their members, shall be as determined by the Member Association.

SECTION 2. (a) For each Active Member the annual dues shall be Five Dollars, payable in advance by the Member Associations to the Secretary of the Federation.

(b) For each Corporate Member the annual dues shall be Ten Dollars, payable to the Secretary of the Federation by February 1 of each year.

(c) For each Sustaining Member and each Associate Member the annual dues shall be as determined by the Board, payable to the Secretary of the Federation by February 1 of each year.

(d) Corporate Members, Sustaining Members, or Associate Members whose dues remain unpaid on March 1 of any year may be dropped from membership on action of the Executive Committee.

(e) The dues for Member Associations outside the United States of America and its territorial possessions shall be greater than the amounts hereinbefore specified by an amount to be fixed annually by the Board as equivalent to the added cost for mailing the Journal to such associations as compared with the average cost for mailing to members residing within these limits.

(f) Active Members, paying full dues, and Corporate Members of Member Associations, and Associate and Sustaining Members of the Federation, in good standing, shall be entitled to one copy each of all publications that are distributed by the Federation to its members.

SECTION 3. The fiscal year of the Federation shall begin on January 1, and annual dues shall be collectible on that date and shall have been paid before February 1. If the dues of any Member Association shall not have been paid by February 1, fifteen days notice of the dues in arrears shall be given to that association, after which time, if the dues remain unpaid, that association may be dropped from the rolls of the Federation on action by the Board, as provided in Article I, Section 3, of these Bylaws.

SECTION 4. Any member, newly elected before June 30, shall pay full dues and shall be entitled to all the publications of the Federation that are distributed to its members during the year. Members elected after June 30 shall pay one-half the regular dues for that year, and shall be entitled to all of the publications distributed during the half year beginning July 1.

SECTION 5. In transmitting dues to the Federation, each Member Association shall forward with them a list of the names, professional titles and correct mailing addresses of all members of all classes of the said Association who are in good standing and are entitled to receive the Journal or other distributed publications of the Federation during the ensuing year.

ARTICLE IV. Duties of Officers and Directors

SECTION 1. The President shall have general supervision of the affairs of the Federation, and shall preside at all conventions of the Federation and meetings of the Board. In his absence the Vice-President shall preside. Should both be absent the Board shall elect the Presiding Officer. The President shall be, ex-officio, a member of all committees.

SECTION 2. The Vice-President shall assist the President in the performance of his duties, and act in his stead when required.

SECTION 3. The Board of Control shall be the legal representative of the Federation, and as such shall manage its affairs subject to the conditions and limitations prescribed in the Constitution and Bylaws; direct the investment and care of funds of the Federation; make appropriations for specific purposes; appoint employees and fix their compensation; take measures to advance the interests of the Federation; and generally direct its business. The Board shall not incur indebtedness beyond the funds in the hands of the Treasurer and the Secretary. The Board shall hold a meeting during the Annual Convention. Other meetings shall be held at the call of the President, or on petition addressed to the Secretary and signed by ten or more members of the Board representing not less than seven Member Associations. Notice of all meetings shall be issued by the Secretary at least fifteen days in advance of such meetings to all members of the Board and to the Secretary of each Member Association. In the event of a vacancy in the office of Secretary, notices of meetings will be issued by the President.

At the Annual Meeting the Board shall appoint a Secretary to serve for a term of two years, unless removed for cause by the Board.

Except as otherwise provided in the Constitution and Bylaws, all questions before the Board shall be decided by a majority vote of those present.

SECTION 4. The Treasurer shall have charge of the funds of the Federation and custody of its investments, if any. He shall pay bills against the Federation when certified by himself and the Secretary. He shall make a report for each calendar year at the Annual Meeting of the Board, showing receipts from the Secretary and other sources, the expenditures, the investments and other assets, and the liabilities of the Federation. He shall make such other reports as may be required by the Board.

He shall be bonded at the expense of the Federation, and to an amount to be determined by the Board.

He shall perform such other duties as may be assigned to him by the Board.

SECTION 5. The Secretary shall be an Active Member and, under the direction of the President and the Board of Control, shall be the executive officer of the Federation. It shall be his duty to attend all conventions and meetings of the Board, prepare the business and duly record the proceedings thereof. He shall see that all monies due the Federation are carefully collected and without loss transferred to the custody of the Treasurer. He shall scrutinize all expenditures, shall certify to the accuracy of all bills and vouchers on which money is to be paid, and shall countersign checks drawn by the Treasurer against the funds of the Federation when such drafts are known by him to be proper and duly authorized by the Board. Once every three months he shall forward to each member of the Board a financial summary of receipts and disbursements, and at the Annual Meeting of the Board shall present a balance sheet of his books as of the 31st of December and as of the 30th of September preceding the meeting, together with a report of the activities of his office.

He shall have charge of the books and records of the Federation, including lists of members of the Federation and subscribers to the Journal. He shall have charge of the mechanical production and distribution of the Journal and other publications of the Federation, and shall handle all financial matters connected therewith.

He shall be bonded at the expense of the Federation, and to an amount to be determined by the Board.

The books of the Federation shall be audited annually at the expense of the Federation by public accountants to be appointed by the Board.

In the event that the Secretary or Treasurer shall be unable to sign checks against the funds of the Federation, the President or Vice-President shall be authorized to countersign such drafts in his stead.

SECTION 6. The Secretary shall serve as Editor of all publications of the Federation and shall receive all manuscript copy and prepare it for publication. He shall have the authority to return to the author for correction, or to reject entirely, any manuscript which may be in bad condition, illegible, or clearly deficient in respect to composition, subject matter or supporting data, or otherwise conspicuously deficient or unfit for publication. He also shall have the authority to reject any manuscript which is designed to promote commercial interests. He shall be a member of the Publications and Program Committee and of the Committee on Sewage and Industrial Wastes Practice. Decisions of the Editor relative to rejection of manuscripts shall be subject to appeal to the Publications and Program Committee.

ARTICLE V. Conventions of the Federation

The Annual Convention of the Federation shall be held at a time and place selected by the Board, preferably in the month of October. All conventions and meetings shall be conducted according to "Roberts Rules of Order," except where provisions to the contrary are noted in any Article herein.

Each member and guest present at any of the conventions of the Federation shall pay a registration fee of such amount as may be determined by the Executive Committee.

ARTICLE VI. Committees

SECTION 1. There shall be an Executive Committee of seven members consisting of the President, Vice-President, immediate Past President and four Directors. This committee shall be chosen by the Board at its Annual Meeting. The President of the Federation shall be Chairman, and the Secretary of the Federation shall act as Secretary of the committee. In the absence of the President, the Vice-President shall preside. The duties of this committee shall be to direct the administrative work of the Federation and carry out the policies of the Board between meetings of the latter. A quorum of the committee shall be four members.

SECTION 2. A Publications and Program Committee shall be appointed by the Board at its Annual Meeting. It shall consist of the Secretary and four or more Active Members of which at least three shall be Members-at-Large. The Publications and Program Committee shall arrange the technical programs for the Annual Convention of the Federation. The committee shall prepare general rules which, after approval by the Board, shall control the preparation, presentation, acceptance and publication of papers and shall have general supervision of such other matters of similar nature as the best interests of the Federation may require.

SECTION 3. An Organization Committee of five Active Members of which at least three shall be Members-at-Large shall be appointed by the Board at the Annual Meeting. The Organization Committee shall examine and report to the Board on application for membership in the Federation and also serve in the encouragement of the formation of new regional or state associations or conferences eligible for membership, as well as serving in an advisory capacity in other matters of a similar nature as the best interest of the Federation may require.

SECTION 4. A Sewage and Industrial Wastes Practice Committee consisting of the Editor and four or more Active Members of which at least three shall be Members-at-Large shall be appointed by the Board at the Annual Meeting.

Any publication which undertakes to establish in the name of the Federation, professional or technical standards shall be submitted by this committee to the Board for approval.

It shall give notice by publication to the membership of all such approved standards and publications.

It shall appoint such subcommittees as it may deem necessary to carry on its work.

SECTION 5. There shall be a Research Committee of five or more Active Members of which at least four shall be Members-at-Large.

The Research Committee shall be charged with the duty of stimulating and coordinating research work among the various Member Associations, and of cooperating with other organizations in the promotion of research work.

SECTION 6. There shall be a Finance Committee of five members consisting of the President, the latest living Past President, the Treasurer, and two Members-at-Large, one of whom shall be appointed Chairman and the other Vice-Chairman. The committee shall present at the Annual Meeting of the Board a budget of estimated expenses of the Federation, including publications, for the ensuing year. On the adoption of the budget by a majority vote of the Board members present, expenses of the Federation shall be limited, as far as may be practicable, within the amounts prescribed in said budget.

The committee shall also function in a general advisory capacity to the Board and to the Executive Committee in all matters relating to finances of the Federation.

SECTION 7. There shall be a Committee on Standard Methods of Sewage and Industrial Wastes Analysis of five or more Active Members of which at least four shall be Members-at-Large.

The committee shall be charged with the duty of developing, perfecting and modifying standard methods for the analysis of sewage and industrial wastes and of sludges or by-products therefrom, and of cooperating with other organizations interested and engaged in similar work.

SECTION 8. There shall be a Committee on Industrial Wastes consisting of five or more Active Members of which at least four shall be Members-at-Large.

The committee shall be charged with the duty of stimulating interest in, and of being of service to industry in the varied problems encountered in the industrial wastes field, including cooperation between Member Associations, and other organizations and agencies.

SECTION 9. Each of the Committees listed in the preceding Sections shall at the time of appointment, include a Vice-Chairman.

SECTION 10. All of the Chairmen and members of the Committees named in Sections 2, 3, 4, 5, 6, 7 and 8, of this Article shall be appointed annually by nomination of the President and confirmation by the Board of Control. The Chairman shall sit in meetings of the Board of Control with full privilege of discussion. None of these Chairmen shall serve more than five years in succession.

SECTION 11. There shall be a General Policy Committee consisting of the President, the three preceding living Past Presidents; and one member representing the Water and Sewage Works Manufacturers Association. The member of the Committee representing the Water and Sewage Works Manufacturers Association shall be nominated by that Association's Board of Governors subject to acceptance by the Board of Control. The Chairman of the General Policy Committee shall be the immediate Past President of the Federation, who is, ex-officio, a member of the Board.

The General Policy Committee shall consider subjects referred to it by the Board, by the Executive Committee of the Board, or by the President; which subjects have to do with general or long-term policies of the Federation.

The recommendations or statements of policy formulated by the General Policy Committee upon any question referred to it, shall be reported to the Board for consideration and further action.

SECTION 12. There shall be a Committee on Nominations consisting of the five latest living Past Presidents, the senior member of which, in point of service, shall serve as Chairman.

SECTION 13. The Board shall appoint such other committees as may be necessary to carry on the work of the Federation.

SECTION 14. The reports and recommendations of all committees of the Federation shall be subject to approval by the Board.

SECTION 15. Members-at-Large are Active Members who are not members of the Board.

ARTICLE VII. Publications

All publications of the Federation shall be issued under the direction of the Board and shall be copyrighted as far as is practicable and proper.

ARTICLE VIII. Amendments

The Board of Control may amend these Bylaws in any manner not inconsistent with the Constitution by the two-thirds vote of those voting at any meeting of the Board or by sealed letter ballot, providing that a copy of such proposed amendment has been mailed by the Secretary to each member of the Board and to the Secretary of each Member Association at least thirty days prior to such meeting or letter ballot.

Consulting Engineers: Whitman and Howard Photo—Dorr-Oliver, Inc.

VAREC SEWAGE EQUIPMENT
helps BURLINGTON, VERMONT keep LAKE CHAMPLAIN clean

"Varec"
SEWAGE EQUIPMENT

- Pressure Relief and Vacuum Breaker Valve
- Flame Arresters
- Flame Trap Assembly
- Explosion Relief Valves
- Waste Gas Burners
- Flame Checks
- Pressure Relief and Flame Trap Assembly
- Pressure Reducing Regulator
- Check Valves
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Burlington, Vermont, has installed the first modern sewage plant in Vermont to protect the waters of Lake Champlain for swimming, fishing and boating.

On the Dorr Multidigestion System, VAREC SEWAGE GAS CONTROL and SAFETY DEVICES protect the plant against fire and explosion, and regulate the volatile sewage gas for smooth operation.

With thousands of communities in the United States and Canada installing Varec Sewage Equipment, it is practically standard for controlling gases from sewage digesters. Send for VAREC Catalog S-3.

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Available from Authorized Sewage Equipment agents throughout U. S. and Canada.

S-13

Proceedings of Member Associations

SOUTH DAKOTA WATER AND SEWAGE WORKS CONFERENCE

The sewage works operators of South Dakota held the 1956 Annual Meeting of the South Dakota Water and Sewage Conference at Aberdeen, S. Dak., on September 19–21, 1956. A total registration of 120 was recorded.

The first general session featured topics of interest to both water and sewage works personnel. These included discussions of federal stream pollution legislation, sewer explosions, and municipal water rights and obligations. Separate sessions were held on the subsequent meeting days, when topics of particular interest to the water and sewage works field were presented.

At the business luncheon the following officers were elected for 1956–57:

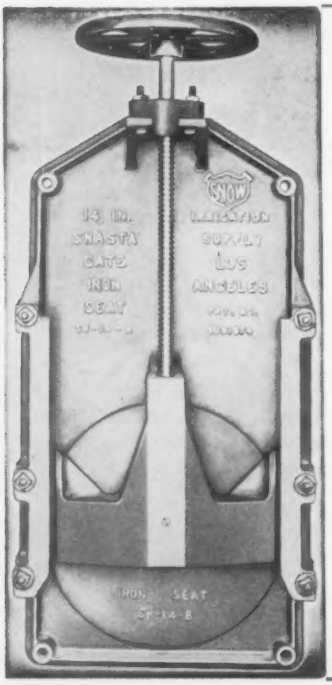
President: Leonard Haddorff, Wessington Springs.
Vice-President: Roy Heiens, Philip.
Secretary-Treasurer: Charles E. Carl, Pierre.

CHARLES E. CARL,
Secretary-Treasurer

CALIFORNIA SEWAGE AND INDUSTRIAL WASTES ASSOCIATION

The 28th Annual Convention of the California Sewage and Industrial Wastes Association was held at Santa

(*Continued on page 120a*)



SNOW GATES
for
SEWAGE TREATMENT PLANTS

All types of cast iron gates manufactured in either square or circular opening in sizes up to and including 72 inches.

ALL SNOW GATES and Lifts are "Parkerized" for protection against rust and corrosion.

Over 40 years continuous service to the industry.

We will be pleased to quote on any type of water controlling equipment.

SNOW GATES & VALVES
2437 East 24th Street Los Angeles 54, Calif.

Largest floating cover digester installation on the West Coast—
San Francisco's North Point Sludge Treatment Plant

At San Francisco, California . . .

10 P.F.T. Floating Cover Digesters installed to gain "Controlled Digestion" advantages

In operation since 1952, this modern plant has a digester capacity of 2,451,000 cubic feet, and handles sewage sludge for a population of 1,169,000. The plant was designed and equipped to effectively control action in the digestion tanks, and to efficiently utilize the large volume of solids.

There are two batteries of five digesters, and a control building for each group. All ten digesters are equipped with 100′ diameter *P.F.T. Floating Covers* for positive scum submergence and safe utilization of gas. The snug-fitting P.F.T. covers eliminate odor problems —an important consideration in this installation because of a residential area close-by. Gas collected under the domes is maintained at constant pressure under all operating conditions, greatly reducing explosion hazards. Capacity is highly flexible, because no fixed levels need be maintained; covers simply rise or lower with additions and withdrawals.

Housed in the control buildings are a total of eight *P.F.T. #1500 Digester Heaters and Heat Exchangers*, equipped with automatic controls. These heaters—using sludge gas as fuel—maintain constant digester temperatures, and also heat the control buildings. Rated heater output capacity is 12,000,000 B.t.u./Hr. Other P.F.T. equipment at this plant includes floating cover position indicators, and a full complement of *P.F.T. Gas Safety Equipment.*

Design of plant by / *Engineering office of Clyde C. Kennedy, San Francisco, Cal.*

P.F.T.

waste treatment equipment exclusively since 1893

PACIFIC FLUSH TANK CO.

4241 Ravenswood Avenue
Chicago 13, Illinois

PORT CHESTER, N. Y. • SAN MATEO, CALIF. • CHARLOTTE, N. C. • JACKSONVILLE • DENVER

Rosa, Calif., April 25–28, 1956. Registration showed a continued annual increase. A record 510 persons were registered, including 127 ladies.

The program featured several interesting sessions devoted to operation and sewer maintenance. These included breakfast sessions on operation, sewer maintenance, industrial wastes, and laboratory practice, as well as workshops for operators and sewer maintenance personnel.

In addition to the technical program, a one-day operators short school was conducted by the Operators Training Committee.

The Bedell Award was presented to Fred G. Nelson, Director of Research, Dorr-Oliver Inc., by Federation Vice-President Emil C. Jensen. Memberships in the Select Society of Sanitary Sludge Shovelers were awarded to Rod T. Antrim, Bob Barletta and Cedric Webster.

Officers elected for 1956–57 are as follows:

President: Eric V. Quartly, San Diego.
First Vice-President: Vinton W. Bacon, Sacramento.
Second Vice-President: Robert D. Bargman, Los Angeles.
FSIWA Director: Rod T. Antrim, Redondo Beach.
Secretary-Treasurer: Robert J. Barletta, Anaheim.

ROBERT J. BARLETTA,
Secretary-Treasurer

PACIFIC NORTHWEST SEWAGE AND INDUSTRIAL WASTES ASSOCIATION

The 23rd Annual Meeting of the Pacific Northwest Sewage and Industrial Wastes Association was held at Boise, Idaho, on October 4–6, 1956. Total registration was 186.

(*Continued on page 122a*)

Control Foam in Your Sewage Aerator with FINE ORGANICS'

FOAMWILT

Here is the efficient solution to foam problems—FOAMWILT—Fine Organics' low cost, easy-to-use product that not only kills off foam, but inhibits its formation.

Fine Organics' FOAMWILT possesses these outstanding properties:

1. Excellent spreading ability
2. Good "knockdown" of foam at ambient temperatures and unaffected by seasonal changes
3. Rapid travel of defoamant
4. Uniformity, stability, and small change in viscosity at temperatures from 0° to + 100° F., allowing outside storage at all temperatures (no clogging of valves and pipes, no separation)
5. Pour point: minus 25° F.

Fine Organics' FOAMWILT is economical to use too . . . it eliminates the need for expensive epuipment or special training. Feed 0.5 to 1 p.p.m. of FOAMWILT with a suitable pump and watch the excellent foam control in your sewage aerator.

Once you use Fine Organics' FOAMWILT, you'll have the efficient solution to your foam suppression problems.

Buy Fine Organics' FOAMWILT for economical and uniformly good control of foam. Write today for full details.

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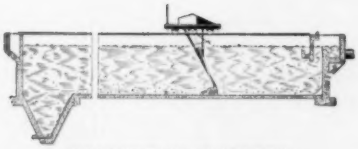
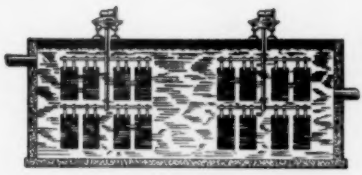
WATER, SEWAGE AND TRADE-WASTE TREATING EQUIPMENT



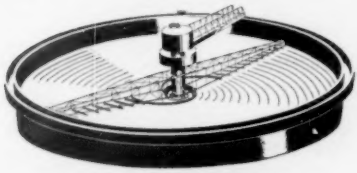
RECTANGULAR CLARIFIERS

Especially suited for limited spaces or where sludge delivery is desired at one end of the tank. A traveling scraper and skimmer carriage removes settled solids from the tank bottom and scum from the top.



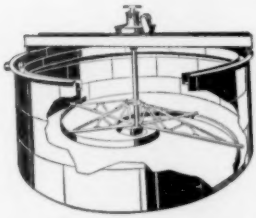
FLOCCULATING UNITS

Slowly rotating paddles on vertical shafts bring the small flocs into contact to form larger masses and hasten precipitation.



CIRCULAR CLARIFIERS

Hardinge Circular Clarifiers are available in sizes up to 200′ diameter, either center-column or beam supported for steel, concrete, wood or tile tanks. Sludge scrapers remove settled solids rapidly through central underflow discharge.

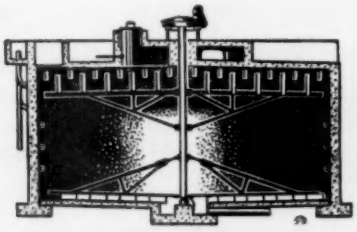


"AUTO-RAISE" THICKENERS

For removal of fine suspended solids from supply water, waste water and sewage. "Auto-Raise" mechanism prevents scraper breakage. Manual or power raise supplements "Auto-Raise." Replaceable ring-type ball bearing support for rotating mechanism. Spiral rakes for maximum underflow density.

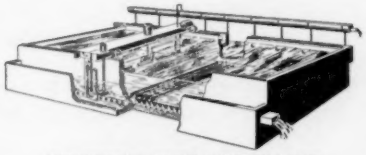
HYDRO-CLASSIFIERS

A large-volume classifier for rapid separation of coarse and fine suspended solids. Frequently used for by-product recovery from waste water.



DIGESTERS

Sludge scrapers and scum breaker arms prevent scum accumulation, insure uniform gas production. Emit a dense digested sludge.



AUTOMATIC BACKWASH FILTERS

For high removal of non-settling or slow settling suspended matter. Self-cleaning sand bed. No shut-down necessary for backwashing. Traveling backwash mechanism.

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COMPANY, INCORPORATED

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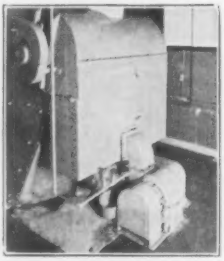
MORE THAN **275** SEWAGE SHREDDERS INSTALLED IN CITIES IN U.S.A.

Convincing proof

SEE the performance of the GRUENDLER SEWAGE SHREDDER in a City, near yours—
(Locations mailed on request)



SINGLE or MULTIPLE UNITS
Installed in connection with Bar Screens of leading Manufacturers

Gruendler Sewage Shredders are very popular where Bar Screens are in use. Debris, leaves, sticks, rags, other matter quickly reduced, assuring an even and continuous flow trough system. Patented features overcome many of the difficult problems. Earlier installations still functioning after 10-15 years of service.

See your Consulting Engineer for data and specifications on Gruendler Units. **or Write us for CATALOG—S.G. 10** without obligation. Contains diagrams for installation, types and sizes of Units including Shredders, Garbage Grinders, Dry Sludge Shredders, Refuse and Compost Grinding Equipment.

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CRUSHER & PULVERIZER CO.
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Two general sessions and one split session were held. The first general session featured three panels—"Sewage Treatment Plants, Their Operation and Maintenance," "Sewer Pipe Construction and Installations," and "Radioactive Waste Disposal." The other general session featured papers on metropolitan area planning and raw sewage waste stabilization ponds.

The Design and Development Section heard two panel discussions—one on dredge mining wastes and the other on grit removal equipment. Additional papers presented were:

"The Effects of Sewage Fertilization in Lakes," by Associate Professor W. T. Edmondson, University of Washington, Seattle, Wash.

"Effect of Cannery Waste Removal on Stream Conditions," by J. V. Lunsford, Assistant Professor, State College of Washington, Pullman, Wash.

The Operation and Maintenance Section heard a discussion on plant operation and maintenance, and the paper "Selling Sewage Treatment by Means of Conducted Tours," by Fred Cooper, Pullman, Wash.

The annual breakfast was held on Friday, October 6. A new event was an evening session for operators only. Field trips were conducted to sewage treatment facilities at Boise, Nampa, Caldwell and Meridian.

Operator awards were made in each of three classes, based on the population size of the community.

Officers elected for 1956–57 were:

President: Andrew J. Wahl, Boise, Ida.

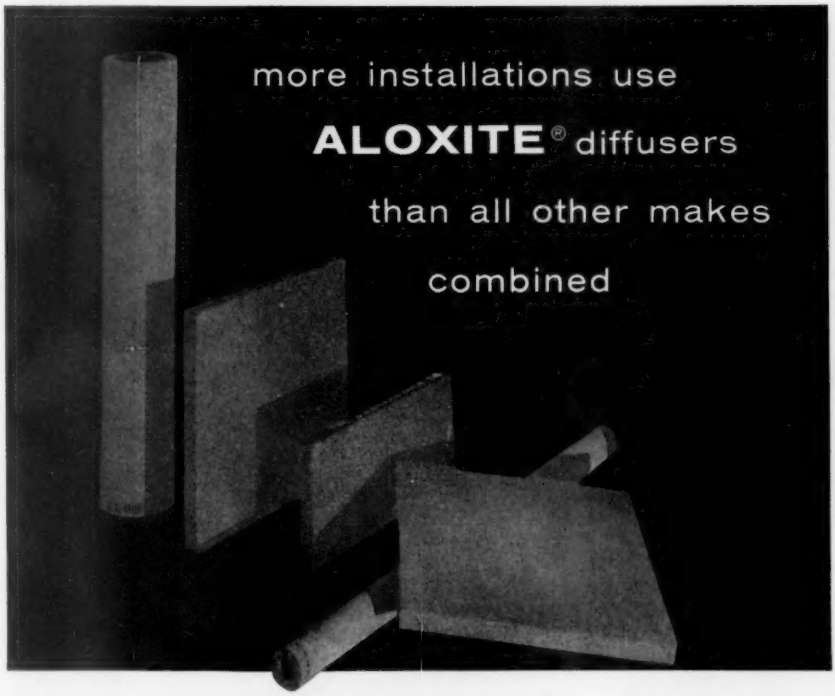
Vice-President: R. Trumbull Smith, Seattle, Wash.

FSIWA Director: H. Loren Thompson, Portland, Ore.

Secretary-Treasurer: Gilbert H. Dunstan, Pullman, Wash.

GILBERT H. DUNSTAN,
Secretary-Treasurer

FIVE REASONS WHY



Since the discovery of the activated sludge process (in 1915) only one diffuser material has stood the test of time. Only porous ceramic diffusers have been used with continued success. And more installations have been made with ALOXITE® aluminum oxide diffusers than all other makes combined. Hundreds are in operation—many after over 20 years' service. Here are 5 reasons why:

1. A highly uniform grain structure in ALOXITE diffuser plates and tubes assures a uniform, small-bubble diffusion. That means optimum oxygen absorption.

2. ALOXITE diffusers have a relatively smooth surface. This fact, coupled with the glass-like ceramic bond that coats each grain, minimizes pressure loss and clogging.

3. ALOXITE diffusers never lose their corrosion resistance.

4. ALOXITE diffuser plates and tubes are adaptable to virtually every cleaning method.

5. ALOXITE diffusers have great strength and ruggedness for long life.

ALOXITE diffusers are available in plate or tube form, and in a full variety of grades. This permits maximum flexibility of design. It also lets you select the exact grade for a given function (consistent with air supply quality, pressure loss characteristics, and over-all life). This is particularly important since the introduction of the oxygen absorption test.

ANSWER ALL YOUR QUESTIONS about porous media with this up-to-date 56-page booklet.

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Write to: **The Carborundum Company, Refractories Division, Perth Amboy, New Jersey.**

Equipment and Supply Lines

Acid Pump—A portable electric acid pump for transferring acids is described in recent releases.—General Scientific Equipment Co., 27th and Huntingdon Sts., Philadelphia 32, Pa.

Perforated Plates—Electrolytically and mechanically perforated plates, screen machine parts and filters, and special welding are now available.—Pyramid Screen Co., 181A Harvard St., Brookline 46, Boston, Mass.

Automatic Sampler—Sampler collects from across the entire stream in adjustable 1-min. intervals from 2 to 55 min. Errors resulting from variations across the stream are eliminated.—Denver Equipment Co., P. O. Box 5268, Denver 17, Colo.

Screener—Centrifugal basket screener permits the recirculation of effluent free from coarse solids.—Patterson-Kelley Co., Inc., 1520 Gaylord Ave., East Stroudsburg, Pa.

Pumps—Medium and high head service pumps are described in 8-page Catalog No. A-155.—C. H. Wheeler Manufacturing Co., 19th and Lehigh, Philadelphia 32, Pa.

Motor Pumps—Completely enclosed, sealless centrifugal pumps for chemical handling and special service are described in Bulletin 1030.—Chempump Corp., 1300 E. Mermaid Lane, Philadelphia 18, Pa.

Pipe Pusher—A powered pipe pusher (or puller) in two models, capable of handling ¾-in. to 4-in. pipe in 21-in. strokes, is now available for placement of underground service piping and conduit.—Mercury Hydraulics, Inc., 2440 Blake St., Denver 5, Colo.

Mixer—Turbine or paddle-type top-entering mixers of rugged, simple design are described in specification sheets for K-series mixers.—Cleveland Mixer Co., Box 197, Bedford, Ohio.

Acid Handling—A carboy truck and a carboy tilter for easy, safe handling of acid carboys are described in a recent release.—General Scientific Equipment Co., 27th and Huntingdon Sts., Philadelphia 32, Pa.

Oiler—A hand-pump pressure oiling system for multiple bearing points is illustrated in Bulletin 36.—Trico Fuse Manufacturing Co., 2948 N. 5th St., Milwaukee 12, Wis.

Activated Silica Feeder—A unit for the continuous preparation and application of activated silica directly from the original shipping containers for sodium silicate and chlorine is described in Catalog No. 60.110.—Wallace and Tiernan, Inc., 25 Main St., Belleville 9, N. J.

Refrigerated Incubator—An improved line of refrigerated incubators with controls and thermometer mounted on the door is available.—Central Scientific Co., 1700 Irving Park Rd., Chicago, Ill.

Electrolytic Conductivity Equipment—Instrumentation for the measurement and control of solution concentration is presented in descriptive Catalog No. 22.—Industrial Instruments, Inc., 88 Commerce Rd., Cedar Grove, N. J.

Chlorine Gas Feeder—High capacity (8,000 lb. per day), visible-flow chlorination unit is described in Bulletin 840-J8A.—Builders-Providence, Inc., 345 Harris Ave., Providence, R. I.

Odor Counteractant—A six-page brochure has been released describing application of "Alamask" odor-control chemicals.—Rhodia, Inc., 230 Park Ave., New York 17, N. Y.

pH Equipment—Applications of pH equipment to industrial wastes and sewage treatment are described in Data Sheet No. 094.1-2.—Bristol Co., Waterbury 20, Conn.

Electric Service Entrance Equipment—New 36-page Catalog TCD-17 presents application and selection data on electrical service entrance equip-

(*continued on page 126a*)

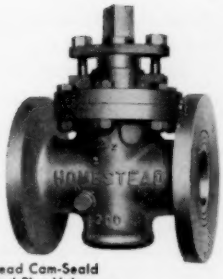
Multiple Port, 100% Pipe Area or Venturi

HOMESTEAD

offers you one source for

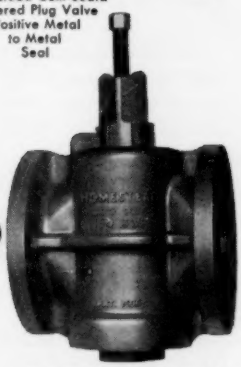
ALL TYPES OF PLUG VALVES

ALL TYPES OF PORT OPENINGS



Homestead Cam-Seald Tapered Plug Valve Positive Metal to Metal Seal

Diamond Port or "V" Port for Throttling

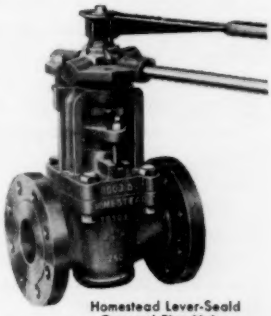


Homestead Lubricated Plug Valve High Pressure Chemical Seal

Round Port 100% Pipe Area

Name the type of valve you need in the metal or alloy you require with the port opening you want—and we can furnish it. Or if you have a valve problem that defies solution, write us, naming the fluid, concentration, temperature, pressure, valve size, function and frequency of operation. We will be happy to recommend the best and most economical valve for your service conditions.

For complete information on Homestead Plug Valves...



Homestead Lever-Seald Tapered Plug Valve Positive Seal Without Lubrication

Rectangular Port 100% Pipe Area

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Please send me information on the following Homestead Plug Valves:

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Rectangular Port Venturi

HOMESTEAD VALVE MANUFACTURING COMPANY

P.O. Box 48 "Serving Since 1892" Coraopolis, Pa.

ment.—General Electric Co., 87 Whiting St., Plainville, Conn.

Sludge Shredders—Shredders for sludge grinding, compost mixing and soil preparation are described in an illustrated release.—Royer Foundry and Machine Co., Kingston, Pa.

Wrought Iron Fittings—Descriptive literature on wrought iron welded fittings and flanges is available.—Tube Turns, 224 East Broadway, Louisville 1, Ky.

Metal Tubing—A light-weight metal tubing produced by winding a thin metal strip into a tube is currently available. The tubing is reportedly inexpensive, resistant to crushing, and easily shaped.—Titeflex, Inc., 10 Hendee St., Springfield, Mass.

Hose—A wire braid, white neoprene hose is available for extra-severe service.—Hamilton Rubber Manufacturing Co., Trenton, N. J.

Roller Bearings—Illustrated Catalog 55 gives complete engineering data, load-rating tables, and dimensions for Shafer self-aligning roller bearings.—Chain Belt Co., Milwaukee 1, Wis.

Chromatographic Apparatus—The research worker will be interested in the wide selection of specialized analytical instruments for analytical distillation and vapor-phase chromatography.—Podbielniak, Inc., 341 East Ohio St., Chicago 11, Ill.

Turbidimeter—A recording turbidimeter for continuous measurement of suspended solids is described in Bulletin GEC-1203A.—General Electric Co., Schenectady 5, N. Y.

Prestressed Concrete Tanks—Current trends in the design and construction of prestressed concrete tanks are described in illustrated Bulletin T-12.—The Preload Company, Inc., 211 East 37th St., New York 16, N. Y.

Chlorinators—A line of V-notch chlorinators, fabricated with corrosion resistant materials, features a direct reading feed rate indicator and a variable orifice. Catalog Nos. 25.100 and 25.110.—Wallace and Tiernan Inc., 25 Main St., Belleville 9, N. J.

Bar Screens—Front-cleaned bar screens for sewage and industrial waste applications are described in illustrated Bulletin No. 315-21.—Chain Belt Co., Milwaukee 1, Wis.

Sewage Pumps—Engineer's reference, Manual 1114, gives detailed information for selecting vertical wet pit pumps and pneumatic ejectors.—Yeomans Brothers Co., 1999 North Ruby St., Melrose Park, Ill.

Polyvinyl Chloride Pipe—Recently released engineering memoranda give detailed data on polyvinyl chloride pipe, valves, and fittings.—Peter A. Frasse & Co., Inc., 17 Grand St., New York 13, N. Y.

Air Filter—An oil bath air filter reportedly combines high efficiency with low pressure loss. The intake air flows over the oil and through a filter element which removes dirt and oil.—Air-Maze Corp., 25000 Miles Rd., Cleveland 28, Ohio.

Chempumps—General purpose, completely sealed pumps for corrosive, toxic, radioactive or other "problem" liquid handling are described in Bulletin 1050.—Chempump Corp., 1300 East Mermaid Lane, Philadelphia 18, Pa.

Grit Collectors—Straight-line chain collection equipment to serve the grit collection requirements of small and large treatment plants is described in illustrated Bulletin No. 315-41.—Chain Belt Co., Milwaukee 1, Wis.

Skimmer—A slotted pipe skimmer, operated on the rack and pinion principle, is available for clarifiers. The skimmer is particularly suitable where tank freeboard is in excess of 3 ft.—Chain Belt Co., Milwaukee 1, Wis.

Flight Collectors—The 20-page illustrated Bulletin 8W68 covers thoroughly flight collectors for rectangular settling basins. Supplementary equipment is also illustrated.—Walker Process Equipment Inc., Aurora, Ill.

Sewage Treatment Equipment—Distinguishing characteristics, types, sizes, applications, and operation of Dorr-Oliver sewage treatment equipment are presented in the 12-page illustrated Bulletin No. 6041.—Dorr-Oliver Inc., Stamford, Conn.

DIRECTORY OF ENGINEERS

(Continued through page 134a)

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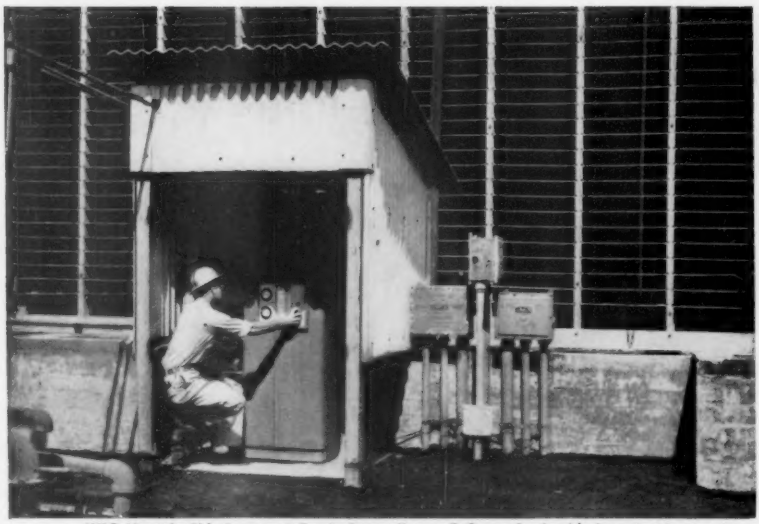

W&T V-notch Chlorinator at Esso's Baton Rouge Refinery feeds chlorine at rates up to 500 lbs./24 hr. over a 10 to 1 feed range. Other V-notch models are available with maximum capacities from 500 to 2000 lbs./24 hr. over a 20 to 1 feed range.

NEW W&T V-NOTCH CHLORINATORS,

are rugged—easy to operate —moderately priced

The W&T V-notch Chlorinator installed at the Esso Standard Oil Co. Refinery, Baton Rouge, La. is housed in a shed open to the sun, weather, and water spray drifting from a cooling tower. The average water or sewage treatment plant operator would consider this rugged service for any piece of equipment.

W&T V-notch Chlorinators have proven in this and other installations that they can withstand rugged service. The design of new V-notch Chlorinators uses not only modern corrosion proof materials but a new concept of chlorine gas control, the W&T V-notch Variable Orifice. V-notch Chlorinators are easy to operate and maintain. They provide the precise chlorine control that is expected from Wallace and Tiernan equipment. In addition, W&T V-notch Chlorinators are an attractive piece of equipment, colored soft green to fit into plant color schemes.

Ask your local W&T representative for more information about W&T V-notch Chlorinators or send for Bulletin S-114.

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